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BULLETIN No. 21 1921 ENTOMOLOGICAL SERIES, No. 1

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J. U. & C. G. LLOYD
CINCINNATI, OHIO

ENTOMOLOGICAL SERIES, No. 1

The Biology of

NORTH AMERICAN CADDIS FLY LARVAE

By
JOHN THOMAS LLOYD

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INTRODUCTION.

Caddis-flies, or Trichoptera, are winged insects with somewhat moth-like appearance, that are mostly nocturnal and usually do not wander far from the watersides. Only rarely do they become conspicuous, and then on account of the great numbers in which they gather about lights, rather than on account of any striking individual habits or appearance. Occasionally they, together with mayflies and insects of a few other orders, congregate about electric lights near large lakes and rivers in such numbers that they become a serious nuisance, and the bodies of their dead collect in piles that must be removed in wagon loads. Usually, however, one who is not making a special hunt for them sees no more than a few individuals that flutter around his light on warm summer nights preceding storms.

Perhaps the larvæ, or caddis-worms—known also as "stick-worms"—are more familiar to the average layman than the winged adults. Almost every child has seen a bundle of crossed sticks jerkily drawn about through the water by an insect with only head and legs projecting. Not all cases, however, are of the cross-stick type, and not all are so familiar to the layman. There are portable cases in almost endless variety of form, and made of almost every material to be found in the water, and there are many larvæ that make no portable cases, but live in silken tubes, awaiting animal prey or plancton to become entrapped in their catching nets. A few caddis-worms make no cases at all, but crawl free among the stones.

Whether the caddis-worms construct portable cases, or silken tubes, or make no cases until almost time for pupation, they all secrete a glue, or silk, through openings in the lower lip, or labium. This silk is produced in large glands within the body cavity. These glands, like the silk-secreting glands of caterpillars, are modifications of the salivary glands, to meet the larvæ's needs for silk. The silk is emitted as a liquid, but has the remarkable character of hardening immediately after expulsion from the larvæ's bodies and of adhering fast to submerged objects, though they be wet and saturated with water. The silk is not usually spun in fine strands, as is that of the Lepidoptera, but is more glue-like, forming a homogeneous sheet over the object cemented.

A few caddis-worms that construct portable cases use no other material than silk in their structure. By far the greatest number of species, however, use stones or sticks cemented around a more or less heavy lining of silk. The cases, regardless of their external form, are circular in cross-section. Some are of uniform diameter, throughout their length, while others taper, cornucopia-like, from a broad mouth to a very narrow caudal end. In building their cases the larvæ add new material to the cephalic end. Some species build rapidly and cut about as much from the caudal ends of their dwellings as they add to the front ends. These species make tubes of uniform diameter throughout their length. Other species add to the front ends of their cases as the larvæ grow in length and breadth, but never remove material from the caudal ends. The result of this form of construction is a case that is of minute size, but large enough to accommodate a newly hatched larva, at its caudal end, and gradually increases in breadth as the larva grows, thus forming a cornucopia-shaped tube. Figures of both types of cases will be found on following pages.

Toward the close of the larval period there is a change in the habits of the caddis-worms. They stop eating entirely and frequently hunt some protected spot, such as crevices in bark or roots, or they burrow into wood or soil. Often the form and material of their cases is greatly altered, and there is almost always a mesh or grating spun across the two ends of the case to protect the helpless pupa against active enemies and the greater peril of silt. After the mesh is spun the larva becomes sluggish and entirely incapable of walking. This stage in the larva's life is called the prepupal period. It usually lasts but two or three weeks, but in the genus Neophylax it extends over the greater part of the summer.

During the active larval period, when the caddis-worms are free to move about and feed voraciously, they lay up a reserve supply of food to carry them through the transformation period and through their adult lives, when they feed little if at all. They then pass through a quiescent or pupal stage. During this period a great change takes place in the structure of the insect. From the worm-like larva, fitted for aquatic life and provided with greatly developed mouth parts and alimentary tract, comes forth a moth-like, winged insect that is air-breathing and has vestigial mouth parts and feeble alimentary tract, and seems to have no other object than to mate and oviposit. So great is the change that no one

could possibly detect the slightest relationship of appearance or structure between the caddis-worm and the adult caddis-fly. Though caddis pupæ are not active, like the corresponding stages in some insects, they are not entirely quiescent. There is always a rhythmic undulation of the abdomen, sending a constant stream of water through their cases, and during the latter part of their lives they are capable of walking.

Trichoptera are the only insects, possibly excepting a very few Diptera (of the genera Simulium and Chironomus), with aquatic pupæ. In several other orders one finds a few species with submerged pupæ, but they all tap the stems of aquatic plants, entrap air in dome-like covers, or in some other way breathe free air. The pupæ or Trichoptera are as much aquatic as are their larvæ.

The eggs of caddis-flies are round or slightly oval in form. The eggs of all, except, perhaps, a few of the Rhyacophilidæ, are laid in masses of gelatin. The masses, when extruded from the bodies of the females, are comparatively small, but rapidly absorb water until they are many times their original size. In form the gelatin mass, and the arrangement of eggs within the mass, is often quite characteristic of the species. In laying the eggs, the females of some species descend beneath the surface of the water and glue the mass fast to some support. Other species dip their abdomens into the water while in flight, apparently washing the extruded mass from the ovipositor, and still other species fasten the eggs to stick or stones above the water, the young falling to the water after hatching.

Very little is known of the eggs and egg-laying habits of most American species.

Trichoptera occur in all parts of the earth where any insects life can exist, but their greatest abundance is reached in the northern temperate zone, and their numbers of species seem to decrease as one nears the equator.

They inhabit all kinds of fresh-water situations, from the most rapid torrents to stagnant swamps and pools. Some species seem to show a decided preference for temporary pools that are filled with water when the autumn rains come, and dry completely with the drought of summer. How these species of Trichoptera, together with some members of several other orders of insects, pass over the period of drought is not altogether certain, but evidence seems to show that they burrow beneath the ground. All known

caddis-worms inhabit fresh water, except a single species from New Zealand that lives in the ocean, and a well-known terrestrial species of Europe that lives in the moss on tree trunks.

In economic importance the Trichoptera rank very high as food for fresh-water fishes. During the summer months the surface-feeding species of fish, such as the trout, obtain a never-failing supply of food from the caddis-flies, as they hover over the surface of the stream and lakes. The larvæ, however, form a much more important article of food for fishes than do the adults. Trout taken from the streams of Ithaca in the early spring are found to have their stomachs gorged with caddis-worms of the genus Neophylax, and to contain no other food. In New Zealand, Hudson examined the stomachs of sixty trout caught at all seasons of the year, and found a total of 5,466 insects. Of these 4,241 were caddis-worms.

Probably no other order of insects is of as great importance in the food of wild trout as Trichoptera, and the day will probably come when caddis-worms are raised by fish culturists as food for their fishes.

In eating caddis-worms, fishes swallow cases and all, their stomach becoming filled with sticks and pebbles, as well as with the bodies of insects.

Aquatic Environment.—To avoid constant repetition on following pages, a brief description is here given of situations in which the greater part of the present work on caddis-worms was done.

Cayuga Lake, a body of water about forty miles long, with an average breadth scarcely exceeding two miles, lies in the valley below the Cornell Campus. It is a deep lake with precipitous sides that rapidly descend to a depth too great for submerged vegetation, except at the two ends, where there are shoals with luxuriant growths of aquatic plants that merge into large cat-tail marshes. The insect fauna of the lake has never been studied.

All of the streams of the region flow into Cayuga Lake. On approaching it they descend rapidly in a series of falls and torrents. In this region of rapid descent their bottoms are of rock and they pass through deep gorges.

Higher up they have more the character of the usual streams throughout the country. They flow in a series of pools with bot-

toms of mud, or silt, or sand, and riffles with bottoms of stones or gravel.

Most of the large streams of the region have their origin in summit marshes, whose drainage often enters two different watersheds. These marshes have bottoms of deep black muck, and are covered with dense growth of vegetation. Alders form almost impenetrable tangles and sedges and grasses, and sometimes bog moss, sphagnum, grow in thick mats under foot, helping to impede the off-flow of water. Through these soft muck bogs the streams meander, their waters always shaded by overhanging alder thickets, supporting hardly any living vegetation. These upland bogs harbor many forms of animal life that are characteristic of such situations, and of the more northern Canadian fauna.

The largest upland swamps are the McLean Bogs and Michigan Hollow, whose southern drainage flows into the Susquehanna River, and whose northern drainage forms Buttermilk Creek, flowing into Cayuga Lake.

More work for the present paper was done in the McLean Bogs than in all other situations together. These bogs are situated along, and near, Beaver Creek, an affluent of Fall Creek, about fifteen miles from Ithaca. They offer not only typical bog conditions, with areas of sphagnum, areas of sedge, and areas of alder swamps, but also several cold swamp streams, an open pond, and numerous large springs.

Since the early days of Cornell, when the hills surrounding the bogs were covered with an impressive growth of huge hemlock trees, till the present time, they have been a favorite collecting ground for students in all fields of biology.

There are also several small lakes in the region. Of these we are concerned with but a few. Beebe Lake, a dilation of Fall Creek, which serves as a reservoir for Cornell University, is convenient to the Campus, but is not very prolific of insect life. Michigan Pond, at the northern end of Michigan Swamp, has soft mud bottom and a profuse growth of aquatic plants. It is a rich collecting ground for aquatic insects. Spencer Lake, in the Susquehanna drainage south of Michigan Swamp, is a beautiful little lake which offers a great variety of aquatic situations. It is rich in caddis-worms, especially the Leptoceridæ.

With these various kinds of aquatic situations within con-

venient working distance, it would be hard to find a spot more favorably situated for work on different types of fresh-water life.

METHODS OF COLLECTING AND REARING.—The methods employed in collecting and rearing the larvæ were quite simple. After the specimens were found, some were put at once into alcohol for future study, and some into formaldehyde for future examination of the stomach contents. Others were caged until the time they emerged, when the species could be determined.

The cages employed were simple cylinders of galvanized screening, over the bottom and top of which a cloth was tied. These cages were placed in natural water as nearly like the situations from which the larvæ were taken as was possible to find convenient to Ithaca. The cages were provided with food material and were partly submerged, care being taken to leave enough space protruding to give the emerged adults ample room above the water.

In carrying living larvæ from place to place it was found that they quickly died if taken from well aerated water and placed in collecting jars. This difficulty was overcome by wrapping them in wet cloths. Experience has shown that aquatic insects will live for long periods of time in cloths that are kept moist, but they must not be left submerged.

In studying the material in the laboratory, balsam mounts were made of the frons, legs, and mouth parts. When possible, the frons and mouth parts were reclaimed from the larval exuvia. This practice eliminates difficult dissections and gives beautiful mounts that are much cleaner than can possibly be obtained by dissection.

For examining the entire larvæ a binocular microscope with various combinations of oculars and objectives was employed.

Many thanks are due to Professor J. G. Needham, Professor O. A. Johannsen, and other members of the staff of the Department of Entomology, Cornell University, for help and encouragement during the preparation of this work.

DISTINCTIVE CHARACTERS OF TRICHOPTEROUS LARVÆ.—Aquatic larvæ[1] having three pairs of jointed thoracic legs and a single pair of abdominal prolegs situated on the last abdominal segment, and terminating in a chitinous hook. All of the abdominal segments are soft, except that some members of the family

[1] Enoicyla, of the European fauna, is terrestrial.

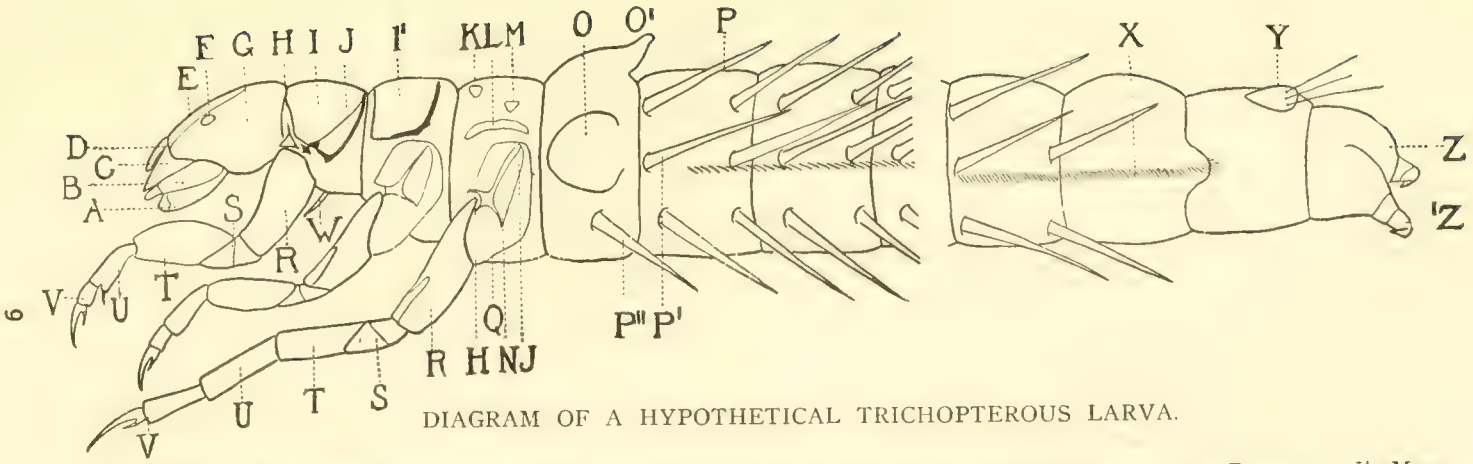


DIAGRAM OF A HYPOTHETICAL TRICHOPTEROUS LARVA.

A—Labium; B—Maxilla; C—Mandible; D—Labrum; E—Frons; F—Eye; G—Gena; H—Episternum; I—Pronotum; I'—Mesonotum; J—Epimeron; K—Cephalic chitinous plate; L—Lateral chitinous plate; M—Caudal chitinous plate; N—Pleural suture; O—Lateral spacing hump; O'—Dorsal spacing hump; P—Sub-dorsal gill; P'—Lateral gill; P''—Sub-ventral gill; Q—Pre-axal swelling; R—Coxa; S—Trochanter; T—Femur; U—Tibia; V—Tarsus; W—Prosternal horn; X—Lateral fringe; Y—Chitinous plate; Z—Proleg; Z'—Drag hook.

Hydroptilidæ have small, dorsal, chitinous plates on certain segments, and a few species in other families have small ventral plates.

Description of the Larvæ. *The Head.*—The head is heavily chitinized. On the dorsal surface there is a somewhat shield-shaped sclerite behind the labrum, which evidently represents the clypeus and the frons, fused into one piece. As the frons represents the larger part of the sclerite, and because the term "frons" is well established in the nomenclature of other orders of insects applying to the clypeo-frons ("clypeus" is used by most writers on Trichoptera), the term *frons* is used to designate the sclerite in the present paper. The shape of the frons varies in different Trichopterous larvæ, and it usually has a quite distinct pattern of color and muscle-attachment marks, as well as different distribution of setæ, for which reasons it is of great use in classification. It is also easily recoverable from the larval exuvia of pupal cases, and often forms the most reliable clue to the determination of pupæ.

Extending back from the frons to the hind margin of the head is the epicranial suture.

On the ventral surface of the head, behind the mouth parts, there is a sclerite, the gula, which varies greatly in size and form. Sometimes it extends to the hind margin of the head, completely separating the epicrania. At other times it is represented by a small, triangular piece, behind which the epicrania are contiguous. At such times the gular suture separates the epicrania behind the gula.

The epicrania form the greater part of the head, extending from the mouth parts to the caudal margin, and from the frons and epicranial suture above to the gula and gular suture beneath.

The antennæ are usually so small that they are easily overlooked; occasionally they are almost as long as the mandibles. They are located behind the outer angle of the mandibles.

The eyes are located on the outer edge of the dorsal margin of the head, sometimes on prominences. They are usually jet black in color and are almost always surrounded by a light-colored area.

The mouth parts are well developed and are formed for biting. The mandibles are very heavily chitinized and offer characters which would be of great taxonomic value, were it not almost im-

possible to get two mandibles into the same position for comparison. When seen from slightly different angles, the form of the mandibles and the comparative size of the teeth, or even the number of teeth, appear very different. Often the mandibles are asymmetrical, differing in their armature of teeth, hairs, and brushes. The labrum is separated from the fused frons and clypeus by a membranous hinge by means of which the labrum folds back within the capsule of the head, often becoming invisible from above without skilled manipulation. The labrum is usually chitinous, but in some families is membranous. It is provided with a few large setæ, often with dense brushes of hairs, and peculiar, cycle-shaped, marginal setæ, which offer good taxonomic characters. The labium and lower mouth parts differ in different families, but only slight study has been given them and they are used but little in classification.

The thorax consists of three distinct segments. The dorsal surface of the first thoracic segment, or pro-thorax, is termed the pronotum, and is always covered by a heavily chitinized plate, which extends over the sides of the segment. On the ventral surface of the prothorax there is often a somewhat curved, finger-like process, of doubtful function, which is found in no other order of insects. It is termed the "prosternal horn" or the "horn." The dorsal surface of the two succeeding segments, the meso- and the meta-thorax, are termed the meso- and the meta-nota. The meso- and meta-notum may each bear from one to four chitinous plates, or they may be entirely membranous. On the sides of the three thoracic segments, forming supports for the legs, are chitinous plates which probably represent the episternum and the epimeron. They offer most excellent taxonomic characters, but as yet are but slightly studied and their use has been almost entirely neglected. All of the plates of the thorax are armed with characteristic spines and setæ.

A pair of jointed legs is borne by each thoracic segment. These often arise from bulbous swellings of the integument of the body which closely resemble the coxæ of certain insects and have sometimes been confused with the basal joints of the legs. Commencing at the basal end of the leg, its segments are as follows: (1) The Coxa, a large, entirely chitinized segment. (2) The Trochanter, usually a short, somewhat triangular segment, that is divided by a suture into two pieces of almost equal length. (In the Lepto-

ceridæ, as discussed under that family, there are variations of the trochanter.) (3) The Femur, usually broad and flattened. (4) The Tibia. (5) The Tarsus, which is a single segment bearing a large claw, usually armed with a tooth.

Gills rarely occur on the thorax.

The Abdomen.—The abdomen consists apparently of ten segments, or apparently of nine segments. All of the segments, except the last, are entirely membranous, except a few Hydroptilidæ which bear small chitinous plates on certain segments, and a few other forms that have some small ventral plates. The first segment in the case-building forms often bears three "spacing-humps," or tubercles. These tubercles are mound-like elevations of the integument that serve to keep a space between the insect and its case for the free circulation of the respiratory currents of water. They are peculiar to the order Trichoptera. One tubercle is located on the middorsal surface of the segment. It often terminates in a movable, nipple-like process. The other two tubercles, the lateral humps, are situated on the sides of the segment and always end obtusely. On the ventral surface of the segment the cuticula is sometimes raised into a lip-like fold, or it may be entirely flat. It is provided with numerous setæ, which are arranged in definite order and often provide convenient means of classification. Some of the segments between the first and the last, of the case-building caddisworms, usually bear a "lateral fringe," or "lateral line." This is a continuous line of delicate hairs, often situated on a fold of the cuticula, which undulate in a wave-like manner from front to rear, and keep a continuous flow of fresh water passing through the case.

Gills, when present, most commonly occur on the abdomen, where they may be situated near the front or hind margin, or near the middle of the segment. They are always filamentous, but they may arise in tufts or singly, they may be branched or unbranched. Regardless of their location in respect to the cephalic and caudal margins of the segments, they are always arranged in rather definite lines known as: (1) The Lateral Series, which is located near the mid-lateral surface of the body. (2) The Sub-dorsal Series, which is located above the lateral series, just below the dorsal surface of the body. (3) The Sub-ventral Series, which is located below the lateral series, just above the ventral surface of the body.

Besides the external gills many trichopterous larvæ possess anal gills, which are located within the anus and are capable of protrusion. In preserved specimens they are usually completely concealed within the cavity of the body, for which reason they offer unsatisfactory taxonomic characters. Even the external gills are not altogether reliable for taxonomic purposes, except in their general grouping; for tufts of gills often contain different numbers of filaments in different individuals of a species, or even on opposite sides of the same individual. Also, especially on the more caudal gill-bearing segments, the gills on some specimens are very feeble, or drop out entirely, while on other specimens they are well represented. However, the same type of gills is always found in the same species, and the gills that are present always arise from the same parts of the segments.

The terminal abdominal segment bears a pair of more or less fleshy prolegs, each of which terminates in a movable chitinous hook. In some of the case-making larvæ the bases of the prolegs are fused, forming an apparent tenth segment, while in other species they are separate, apparently arising from the ninth abdominal segment. Ulmer considers ten segments usually present, but the weight of evidence points to but nine segments, the apparent tenth being but the fused bases of the prolegs.

Description of the Pupæ.—In external appearance Trichopterous pupæ have many of the characters of the adults. Their legs, antennæ, and wing-pads are free from the body, and their general form is much the same as that of the perfect insect.

The head is formed much like that of the adult. In those forms that have antennæ shorter than the body, the antennæ are straight and are laid close along the sides of the pupæ. In forms with antennæ much longer than the length of the body they project backward along the sides of the insect until nearly reaching the end of the abdomen, when they turn abruptly and entwine round and round its caudal segments. The labrum is very different from that of either larva or adult. It is armed with several very long spines which probably serve to keep the mesh of the pupal case free from silt. These spines have characteristic form and grouping in different species. The mandibles are long and heavily chitinized, usually possessing several sharp teeth. It

FAMILY CHARACTERS OF TRICHOPTEROUS LARVÆ.

Prolegs not fused in median line to form an apparent tenth segment.

FAMILY	BREADTH OF ABDOMEN	DORSAL SURFACE OF 9TH ABDOMINAL SEGMENT	TRACHEAL GILLS	LABRUM	LENGTH OF FRONS
HYDROPTILIDÆ	Much wider than thorax	With chitinous shield	Absent	Entirely chitinized	Normal
RHYACOPHILIDÆ	Not much wider than thorax	With chitinous shield	Absent	Entirely chitinized	Normal
HYDROPSYCHIDÆ	Not much wider than thorax	Without chitinous shield	Present. Branched	Entirely chitinized	Normal
PHILOPTOMALIDÆ	Not much wider than thorax	Without chitinous shield	Absent	Entirely membranous. White.	Normal
POLYCENTROPIDÆ	Not much wider than thorax	Without chitinous shield	Absent	Entirely chitinized	Long. The epicrania barely meeting behind its caudal margin
PSYCHOMYIDÆ	Not much wider than thorax	Without chitinous shield	Absent	Entirely chitinized	Normal

is thought that they are used in cutting through the case at the time of emerging. The maxillary palpi are well developed and have the same number of segments as those of the adults.

The thoracic segments are formed much like those of the adult. The second and third segments have external wing-pads, and all three segments possess jointed legs. The legs are much like those of the mature insect, but often possess long swimming hairs to enable the pupa to reach the surface of the water and a suitable place for transformation.

The abdomen is formed much like that of the imago, but is usually longer and more flexible. Gills and lateral fringe are common among the pupæ. Usually they are found in the same species that possess them as larvæ, but this rule does not always hold true. The dorsal surface of segment one usually bears a chitinous structure that may be paired or single. Its general form, together with its ridges and teeth, offers good family and specific characters. Other segments of the abdomen bear paired chitinous plates near their anterior margins, with armature of stout teeth or hooks directed forward. Besides these, segment five bears a pair of plates on its posterior margin, with teeth directed forward. Rarely similar plates are found on the caudal margins of one or two other seg-

FAMILY CHARACTERS OF TRICHOPTEROUS LARVÆ.

Prolegs fused in median line to form an apparent tenth segment.

FAMILY	TRACHEAL GILLS.	DORSAL SURFACE OF LABRUM	BREADTH OF LABRUM	MESONOTUM	METANOTUM	FEMUR OF HIND LEG
CALAMOCERATIDÆ	Filamentous	With row of 20 or more heavy bristles	Broader than long	Chitinized	Soft	Not divided
ODONTOCERIDÆ	In bunches	Normal	Much longer than broad	Chitinized	2 narrow plates crossing median line and 2 small lateral plates	Not divided
SARICOSTOMATIDÆ	Absent, single or bunched	Normal	Broader than long	Chitinized	Soft	Not divided
MOLLANIDÆ	In bunches or branched	Normal	Broader than long	Chitinized	Soft	Not divided
LEPTOCERIDÆ	Absent, single or bunched	Normal	Broader than long	Chitinized	Soft	Divided or apparently so
PHRYGANIDÆ	Unbranched, lateral series with black hairs	Normal	Broader than long	Soft or with one pair of minute plates	Soft	Not divided
LIMNOPHILIDÆ	Single, bunched or branched. Never with black hairs	Normal	Broader than long	Chitinized	With 3 pairs of plates	Not divided

ments. This armature, except that of segment one, is subject to so much individual variation that it is of little systematic importance.

The caudal abdominal segment bears long, slender processes armed with long spines. These are probably used, like the long spines on the labrum, to keep the mesh of the pupal case free from entangled silt.

Toward the end of the pupal instar it is possible to see many of the adult characters through the pupal skin. Thus the armature of the legs and the character of the genetalia can be easily compared to those of the adult.

The North American Caddis-Fly Larvæ

FAMILY PHRYGANEIDÆ.

Of the three of four genera of Phryganeidæ occurring in North America, only two genera, Neuronia and Phryganea, have been recorded in the eastern part of the United States. Of these the genus *Phryganea* has four species and *Neuronia* has eight species in this region; three of each genus are known in the larval and pupal stages. The eggs of only one North American species, *Phryganea interrupta,* are known.

The larvæ of the family are usually among the first aquatic insects attracting the attention of students of entomology. Large, brightly colored, caterpillar-like insects that jerkily drag their cases about in the clear waters, they can not pass unobserved.

Though the larvæ do move about and feed in the daytime, they are typically creatures of the night. If one watches them in an aquarium he will find that a large part of the day is spent in rest, with the front end of the case fastened to some support by a film of silk. When night comes, the cases are loosened and the larvæ crawl actively about, greedily feeding upon whatever vegetation their abode affords.

The immature stages of the Phryganeidæ are better known than those of any other family of American Trichoptera. Our better knowledge of them is perhaps due to their conspicuousness and the ease with which they can be fed and reared in captivity. Omnivorous plant feeders, and dwellers in ponds or slowly flowing streams; furnished with a great area of gill surface which is constantly bathed with changing water pumped by the unceasing rythmic waves of the body, they thrive in laboratory aquaria.

The greatest danger that besets the captive larvæ, when several are confined together, comes at the time of pupation. After the earliest have attached their cases and have become inactive, they fall easy prey to the ravenous appetites of those still active. In nature, however, due to the burrowing habits of the larvæ before their activity ceases, it is probable that they are seldom disturbed by others of their kind.

Distinctive Characters of the Larvæ.—The larvæ are brightly colored with dark-brown or black on the yellow background of the heavily chitinized parts of the head and prothorax. The abdomen and soft parts of the meso- and meta-thorax, in life, are green or reddish green.

The body in cross-section is almost circular. The head turns down at an angle of about 45 degrees; the last abdominal segment also turns down. The prothorax is heavily chitinized above the coxæ and bears no tufts or setæ; the meso- and meta-thorax are entirely soft except a minute pair of bristle tufts. The gills are finger-like and arise singly, the postsegmental gills of the median series bear fine black hairs—continuations of the lateral fringe.

Description of the Larvæ.—*The Head.*—The head is long and somewhat flattened. Each antenna consists of a single short cylindrical segment set in a pyramidal base. The tips of the ventral margins of the epicrania are almost contiguous behind the somewhat triangular gula. The labrum is broader than long, rounded into two lobes which are separated in front by a narrow area having its edge indented into about eight scallops; the margins of the labrum are bordered with a rather sparse fringe of hair; four setæ on the margin are pale in color and are curved inward so that they lie almost parallel to the margin, the other setæ are normal; on the under side there are three pairs of spearhead-shaped setæ with their points directed inward, these show through prepared mounts and often appear as if on the upper surface. The mandibles are stout, with more teeth on the left mandible than on the right; brushes on the mandibles are wanting. The lower mouth parts are well developed; the maxillary palpæ and maxillary lobes are about equal in length.

The Thorax.—The prothorax is heavily chitinized above the base of the forelegs. The venter is soft, except the somewhat triangular sternellum. The "horn" immediately in front of the sternellum is long, slender, and curved forward. The pleural suture is sunken, giving a grooved appearance to the hind margin of the segment. The trochantine is acute and spur-like, extending beyond the margin of the foreleg. Clusters of setæ are lacking.

The meso- and meto-thorax are soft, except the heavily chitinized episterna and epimera. On the dorsal surface of each of

these segments there is a pair of slight prominences, each of which bears clusters of about five large and several smaller setæ.

The legs are long, and terminate in slender, curved tarsal claws; those of the first pair are shortest and stoutest, while those of the third pair are longest and most slender. The inner margin of each femur and trochanter is fringed with a dense single line of pale hairs.

The Abdomen.—The segments are deeply constricted at the sutures, giving the abdomen a decidedly ringed appearance. The spacing-humps on the first segment are large; the dorsal hump is directed backward and bears a pointed nipple-like process at its tip; it is apparently incapable of motion; the lateral humps lack the nipple-like process and can be moved at the will of the larva. The lateral fringe is black, sparse in front, and growing increasingly denser toward the rear; the gills are long and finger-like, and are arranged singly; on each segment the hind gills of the medium line are stoutest and lie close to the body; their firm articulation makes it apparently impossible for them to sway in currents, as do the other gills; these postsegmental gills bear fine black hairs—continuations of the lateral fringe. On the dorsal surface of the ninth segment there is a raised chitinous plate which bears four prominent, and several small, setæ on its hind margin. Above each proleg there is a line of several setæ.

Description of the Cases.—The cases are cylindrical tubes of thin, rectangular bits of leaves arranged spirally (Phryganea, fig. 41) or in a series of rings (Neuronia, fig. 18). The lining is a thin sheet of tough but pliable silk.

Key to the Genera of Phryganeidæ Larvæ.

A. Frons with median stripe, or with no markings. Case a spirally wound cylinder.—*Phryganea.*

A.A. Frons with dark markings, which are not in the form of a median stripe. Case a cylinder composed of rings of leaf sections placed end to end.—*Neuronia.*

Key to the Genera of Phryganeidæ Pupæ.

A. Mandibles lance-like, or sickle-like, several times as long as broad.—*Phryganea.*

A.A. Mandibles rhomboidal, only slightly longer than broad.—*Neuronia.*

Genus Neuronia.

Habitat.—Neuronia larvæ may be found in our fauna almost wherever there are slowly moving streams of spring water. Rarely they are found along the edge of the large warm streams where cool seepage enters. They prefer slowly moving water, but seem to have little preference whether it be a shallow seepage, barely deep enough to submerge their cases, or the deep pools of upland streams. In still water only *N. concatanata* has been taken. This occurs in Michigan Pond.

Larval Habits.—The larvæ of Neuronia are bottom-dwellers whose habit is to crawl over the floor of their cold spring stream, or to rest among its trash and litter. They can, and do at times, climb about on the vegetation, but typically they are of the bottom.

When the season for pupation draws near, the larvæ of Neuronia burrow into wood, or wedge themselves beneath bark, or in crevices, as do the larvæ of Phryganea, or if the stream bottom be of clay they may burrow into the soil itself. Pupal life beneath a loose, silty soil would be fatal.

Larvæ pupating under natural conditions, as described above, do not shorten their cases. If kept in an aquarium, where opportunities for burrowing are not at hand, the larvæ will cut off the case to a length slightly longer than its body and attach it to some supporting plant for pupation.

Food of the Larvæ.—Leaves of all kinds and in all states of preservation enter into the food of Neuronia larvæ. Dead leaves, however, are more frequently consumed than the leaves of living plants, but the choice seems due to the chance of environment rather than to a preference of appetite. On the bottoms of the streams where Neuronia occur, green plants are scarce. When they do occur they are eaten without discrimination.

Distinctive Characters of the Larvæ.—The only characters yet discovered for separating the larvæ of this genus from those of Phryganea are the color pattern of the frons. All known larvæ of North American Neuronia have lateral markings on the frons, which may connect in U-like forms across the caudal region of the sclerite. A median stripe is never present.

The larvæ are slightly more robust than those of Phryganea.

The spacing-humps are larger, and the abdominal segments less constricted, giving the larvæ a less scalloped appearance.

Distinctive Characters of the Pupæ.—The pupæ of Neuronia may easily be distinguished from those of Phryganea by their short rhomboidal mandibles, almost as broad as long.

Description of the Case.—The cases of the known species of North American Neuronia are easily distinguished from any other known cases. They have the form of very slightly bowed cylinders, varying in length, but always much longer than the body of the larva, and tapering very little, if at all. The cylinders are composed of a series of rings placed end to end. Each ring is made of broad quadrilateral sections of leaf. The rings are neatly fitted without overlapping, in the cases of old larvæ. Young larvæ sometimes leave the caudal ends of the leaf fragments protruding in long strips.

The cases of the larvæ of American Neuronia differ remarkably from those of the European members of the genus. In Europe the cases are described as spirally built, like those of Phryganea. When a careful study of the adults and larvæ from America and Europe is made, it may be found that there are generic differences of structure correlated with this difference of habit in case-making.

Key to the Species of Neuronia Larvæ.

A. Mesonotum without chitinous plates. Frons with a dark mark on each side, not connected to form a U-like pattern.—*N. postica.*

A.A. Mesonotum with two minute chitinous plates near its cephalic margin. Frons with the dark marginal marks connected behind to form an irregular U-like pattern.

B. Robust larvæ measuring 30 mm. when mature. Markings dark.—*N. pardalis.*

B.B. Less robust larvæ, not exceeding 20 mm. in length. Markings less prominent than in N. pardalis.—*N. stygipes.*

Neuronia Pardalis.

Habitat.—The larvæ have been taken only in Argus Brook and in the old mill-race, at McLean, but adults on the wing in Michigan Hollow and in Bear Swamp indicate that the species also breeds in those localities.

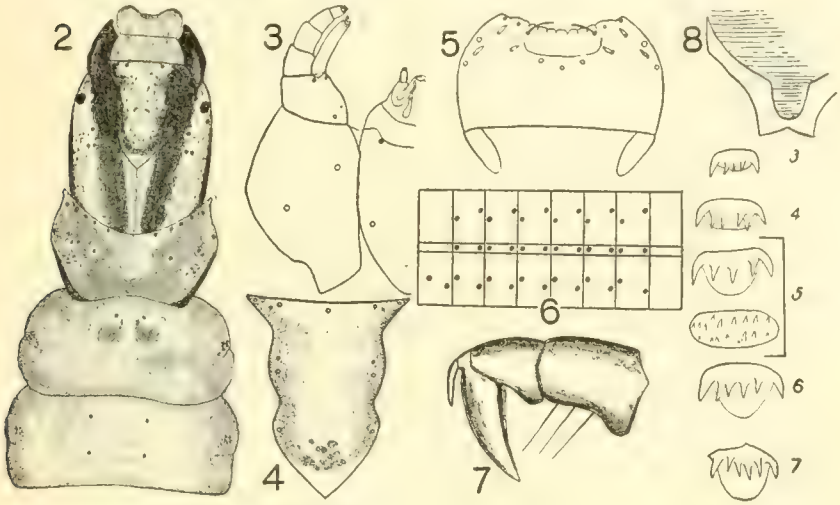
LARVAL HABITS.—The habits of *N. pardalis* do not seem to differ from those of *N. postica*.

PREPUPAL HABITS.—No pupæ were taken under normal conditions, but probably, if known, their habits would be found like those of other members of the genus.

In captivity, where no opportunity for burrowing was offered, the cases were tightly attached to vegetation before pupation took place.

FOOD OF THE LARVÆ.—No stomach examinations were made, but the food eaten in captivity does not differ from that taken by *N. postica*. Probably in nature the diet of the two species is the same.

DESCRIPTION OF THE LARVA.—Length, 32 mm.; breadth at second abdominal segment, 5 mm.



NEURONIA PARDALIS.

2. Larva. Head and thorax.
3. Larva. Lower mouthparts.
4. Larva. Frons.
5. Larva. Labrum.
6. Larva. Distribution of giills.
7. Larva. Drag-hook.
8. Pupa. Chitinous plates of left side of abdomen.

The Head.—Light straw color with black markings arranged on the dorsum as in figure 2; on the side there is a black mark commencing at the prothorax and ending a short distance behind

the eye, the upper margin of this mark is bordered by numerous small round spots and near its cephalic end a narrow line extends downward, connecting it with the black mark of the venter; each side of the venter is marked by a broad black patch which extends from the base of the mandibles to the caudal margin of the head; the mandibles are jet black, except for a brown mark on the outer margin.

The Thorax.—The markings of the dorsum are shown in figure 2; on each side of the third segment a sharply defined black mark extends obliquely upward to the caudal margin of the segment; on the venter there is a black, somewhat triangular mark reaching from the caudal margin of the segment to the base of the "horn;" the "horn" is light in color and apparently weakly chitinized. The second thoracic segment has a group of about eight setæ in a light-colored area on each side of the dorsum; the sides, except the legs, are without markings; the venter is without markings; the third segment has a group of about eight setæ on each side of the dorsum, its sides and venter are without markings.

The legs are straw-color marked with black.

The Abdomen.—In life it is dark-green with a distinct reddish tinge, especially on the dorsal side; the gills are pale reddish; the arrangement of gills is diagrammatically shown in figure 6.

Description of the Pupa.—Description made from a cast skin. The mouth parts are weakly chitinized; the labrum is rectangular with rounded corners, about 1.5 times as long as wide; the mandibles are about half the length of the labrum and are almost as broad as long, a projection on the outer side bears two prominent setæ on its tip; the lateral fringe commences on the cephalic margin of the fifth abdominal segment and loops under the caudal margin of the eighth segment; a pair of sucker-like discs occurs on the dorsal surface of the caudal margin of the last abdominal segment; each disc has a single seta on its outer margin and a group of three large setæ beneath its cephalic margin; the first abdominal segment has a striate appearance above, as in figure 8. The arrangement of teeth on the dorsal plates is serially illustrated in figure 8.

Neuronia Postica.

Habitat.—This species is found in cool, slowly moving streams, fed by springs or in drainage from upland bogs. Like

other members of the genus, it prefers the deep shade of the forest, and is often found in streams which are littered with leaves but void of living vegetation. It occurs sometimes where the seepage from bogs furnishes scarcely enough water to submerge its case, and at other times it is found on the bottom of the deepest pools of upland streams. In the Cayuga Basin it is the most widespread member of the family.

Larval Habits.—The larvæ spend their days crawling about or resting among the leaves of the stream. At night they are more active and feed almost unceasingly. They are bottom-dwellers that seldom climb into the vegetation.

Unlike members of other genera of Trichoptera, this species, and probably other species of the genus, frequently abandon their cases. Often during spring the larvæ may be found without their cases, and in the winter they have been observed through the thin ice crawling naked among the leaves on the stream's bottom. When they enter submerged trash their cases prove cumbersome, and are abandoned. How frequently this occurs one comes to realize when, while seeking the larvæ, he encounters case after case without its occupant, and seldom a case inhabited. The form of the case, also, indicates that they are not long retained. Their uniform diameter proves that they are constructed more rapidly than the diameter of the larvæ increases.

That larvæ under natural conditions often find and enter their deserted cases is improbable, but in captivity the cases are usually reclaimed. Often, when several specimens are kept in the same aquarium, a caseless larva will enter the rear end of an inhabited case, crowding the owner out before him. The owner, when so treated, almost invariably crawls down the outside of the case and himself enters at the rear. Thus ownership many times alternates until finally one becomes discouraged and abandons the case to the other.

A few weeks before time for pupation the larvæ seek places of safety in which to spend their inactive period of metamorphosis. Their hiding place may be the thick mat of roots along the stream's edge, or it may be the soil of the stream's bottom, but more often it is a water-soaked root or log.

When pupation takes place among roots, the larva crawls deep into the thickly entangled root-mat of the bordering alders, where

it makes its case fast with a cement of silk. Here it is protected against the ravages of prowling enemies and against the greater danger of suspended silt.

Those larvæ which transform in the earth of the stream's bottom, enter the soil where it is firm and hard; submergence in silt would mean their destruction. When entering the soil the larva stands on its head, with its case perpendicular to the bottom, and slowly enters, dragging its case with it. I do not know by what method digging is accomplished.

Food of the Larvæ.—The larvæ eat vegetable matter of almost every kind. In the laboratory they show little preference between dead or living plants, terrestrial or aquatic. Under natural conditions, as shown by examinations of stomachs of larvæ taken in the streams, both dead leaves and fresh aquatic plants, when the latter are to be had, are consumed.

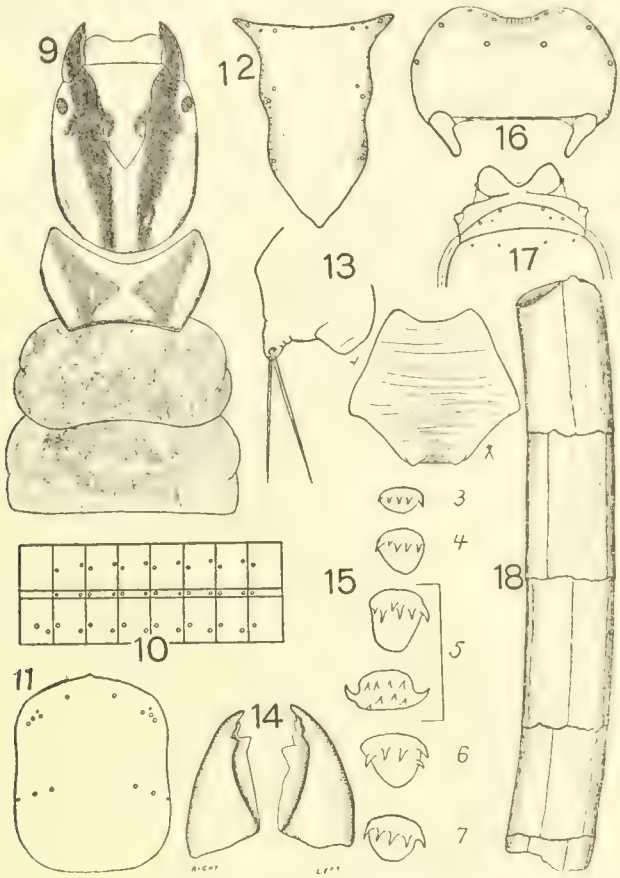
Period of Emerging.—The imagoes first appear early in May and continue to emerge until late June. In emerging, the pupæ swim to the surface of the water, transform, and take flight without climbing onto any support. Their cast pupal skins are often common objects along the margins of upland streams.

Description of the Larva.—Length, 30—35 mm.; breadth, 4.5—5 mm.

The Head.—Straw-yellow marked with dark-brown as follows: A mark starting at the base of each mandible extends diagonally back along the outer edge of the frons to the hind margin of the head, almost touching the epicranial suture; a mark begins behind and slightly below each eye and extends to the hind margin of the head, almost paralleling the upper mark; a white area surrounds each eye. The under side of the head is slightly cloudy, but does not have the well-developed smoky stripe of *N. stygipes.* The mandibles are dark-brown, except for a triangular spot on the outer surface, which is lighter. The labrum and the sclerites of the lower mouth parts are straw-colored, narrowly bordered with brown.

The Thorax.—The prothorax is straw-yellow, marked with dark-brown; the pattern of the dorsal surface is shown in figure 9. The epimeron is dark-brown, narrowly bordered with black; the ventral side of the prothorax is white, with a triangular black chitinous piece behind the "horn."

The meso- and meta-thorax on their upper surface are without dark marks, but have a pattern of minute white spots arranged in narrow lines (figure 9); the arrangement and extent of this pat-



NEURONIA POSTICA.

9. Larva. Head and thorax.
10. Larva. Distribution of gills.
11. Pupa. Labrum.
12. Larva. Frons.
13. Pupa. Mandible.
14. Larva. Mandibles, under side.
15. Pupa. Chitinous plates of left side of abdomen.
16. Larva. Labrum.
17. Pupa. Caudal end of abdomen. Ventral side.
18. Case of larva.

ern is subject to some variation; the ventral surface is without marks. The epimeron is brown, with a narrow black mark in the form of an inverted T.

Abdomen.—The distribution of gills is indicated in figure 10.

Description of the Pupa.—Length, 20—25 mm. The mouth parts are weakly chitinized. The labrum is rectangular, with rounded corners, about one and a half times as long as wide (figure 11). The mandibles (figure 13) are a little longer than wide; a broad lobe on the inner corner of the front margin is without setæ; a smaller, somewhat finger-like lobe on the outer corner bears a pair of long setæ on its tip.

The lateral fringe commences on the cephalic margin of the fifth abdominal segment and loops under the caudal margin of the eighth segment. The last abdominal segment is deeply notched, as shown in figure 17; the sides of the notch are flat and disc-like on their dorsal surface. The shield on the dorsal surface of the first abdominal segment is finely striated with transverse marks, as shown in figure 15. The chitinous plates of the succeeding segments are shown in the same figure.

Neuronia Stygipes.

Habitat.—The only locality record for the immature stages of this species is a short area near the headwaters of Argus Brook, in the McLean bog. In this region the larvæ are not uncommon.

Larval Habits.—The larvæ wander actively about through the trash of the stream's bottom until the middle or latter part of April, when they burrow into the soil or into dead wood for pupation.

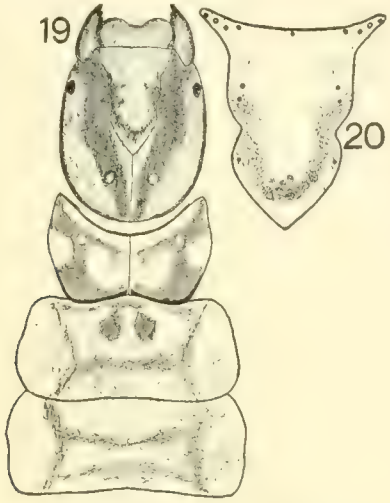
Period of Emerging.—The habits of the species when emerging are like those of *N. postica.* In captivity emergence took place during the last two weeks of May. During the same period adults were common along the stream where the larvæ were found.

The adults were seen only close to the stream from which they emerged. Here they flew about with slow, jerky flight close to the low vegetation beneath the dense alder thicket, or skimmed the surface of the small stream. When resting they sought the shelter of low weeds or grass.

Due to their habit of flying during the light of day, and of remaining close to the borders of the stream, the adults of this species are more readily seen than are those of other species of the genus, which are nocturnal and wide wanderers.

FOOD OF LARVÆ.—The stomachs examined contained nothing but fragments of disintegrated leaves—the only soft vegetable matter in the stream where the larvæ were found. It is probable that this species, like *N. postica,* has little preference for the kind or condition of the leaves it eats, and that the variety of its diet is in about the proportion of the variety of the soft plant materials in the water it inhabits.

DESCRIPTION OF THE LARVA.—Length, 20 mm.; breadth, 3 mm. No structural or color characters have been found to separate the larva of this species from *N. pardalis.*



NEURONIA STYGIPES.

19. Larva. Head and thorax. 20. Larva. Frons.

Head.—Straw-yellow marked with dark-brown, as shown in figure 19. A dark-brown mark starting at the base of each mandible extends diagonally back parallel to the outer margin of the frons, to the hind margin of the head, where the two almost touch the epicranial suture; a dark-brown mark begins slightly behind and a little below each eye, and extends back to the hind margin of the head; on the under side from the mouth parts to the hind margin the head is clouded with smoky brown; between this clouding and the postocular mark the straw color of the head is unshaded; a narrow white area surrounds each eye. The frons (figure 20) has the straw-yellow ground color of the rest of the

head; a dark-brown mark begins slightly behind each mandible and follows the inner margin of the frons until nearly reaching its caudal angle, where it makes a U-like curve, leaving a small area of the caudal part of the frons unmarked.

The Thorax.—The sternum of the prothorax is straw-yellow, the dorsum marked with a somewhat variable pattern of smoky brown, as shown in figure 19; the episternum is smoky brown in color, narrowly bordered with deep black along its hind and lower margins; on the under side the prothorax is straw-yellow, except the chitinous triangle, which is dark-brown. The mesothorax has a variable pattern on its dorsal surface; it also has two dark-colored chitinous plates near the mid-dorsal line. The metathorax has a variable pattern on its dorsal surface.

The Abdomen.—The soft abdominal parts of the material at hand have been injured by drying.

Genus Phryganea.

Habitat.—In this region Phryganea larvæ have been found only in the ponds and pools of the Renwick marshes and in Michigan Pond. Occurrence of adults at Sheldrake Point, where there are similar ponds, and on the campus, near Beebe Lake, makes it seem probable that the genus is not uncommon where suitable ponds of thick submerged vegetation exists.

Larval Habits.—Phryganea larvæ dwell, for the most part, among submerged plants above the water's bottom. They are among the few Trichoptera larvæ that can readily be taken with a water net. In moving from place to place, however, when the branches of the supporting plants are not intermixed, they must become bottom-crawlers. Unlike Triænodes, a genus of Leptoceridæ, with which their cases and habits have some things in common, they are not provided with swimming hairs, and are incapable of progress by swimming. Phryganea larvæ differ from the larvæ of Neuronia in their persistent occupation of their cases. They never abandon their cases to wander naked through the water. Correlated with this habit one finds their cases more tapered than those of Neuronia, indicating that they have been retained through a period of growth.

In preparing to pupate, the larvæ of Phryganea leave their abode among the living plants and travel to some submerged log

or chunk of wood. Here they turn at right angles to the surface and slowly burrow into the wood until the last bit of the case is concealed. The operation sometimes requires several days of labor. When sufficient depth is reached the larva spins a silken mesh across each end of the case.

Sometimes, when the bark of the log is loose, the larvæ take advantage of the natural condition and pupate between the bark and the wood, or they may wedge themselves into some natural crevice. Boring into the wood, however, seems the most common method of concealment.

Food of the Larvæ.—Stomachs of larvæ taken under natural conditions contained green plant tissue of various species. Apparently the larvæ feed upon green tissue because of their habit of living among living plants, where the accumulation of dead material does not occur, rather than through any choice of appetite. In aquaria, among a mixture of living and dead plants, they displayed no preference for either sort. Each was eaten with equal greed.

Description of the Larvæ.—The larvæ of the known species of North American Phryganea can most easily be distinguished from the larvæ of Neuronia by the color patterns of the frons. In Phryganea the color is confined to a medium stripe, except in *P. vestita,* in which a pattern is entirely absent.

The larvæ are slightly more slender than those of Neuronia. The spacing-humps are not quite so strongly developed, and the abdominal segments are more rounded, giving them a more pronounced scalloped appearance.

Description of the Pupæ.—The pupæ of Phryganea differ from those of Neuronia in having long, slender, lance-like mandibles—many times as long as broad.

Description of the Case.—The cases of Phryganea have the form of straight tubes (figure 41) composed of narrow strips of leaf arranged in spiral form around the circumference of the case. The spiral of the same species is sometimes wound from right to left, sometimes from left to right. The cases of mature larvæ are tapered very slightly, if at all, but those of immature larvæ taper much more than do those of immature Neuronia larvæ. The young of both genera often fail to cut the leaf fragments used in

the construction of their cases into the rectangular form characteristic of older larvæ. Such cases, (figure 40) with their long, protruding ends of leaves, appear superficially very different from those of mature larvæ. Careful examination beneath the protruding ends, however, will reveal the characteristic ringed or spiraled arrangement of the bases of the untrimmed leaves.

The cases of Phryganea larvæ might, from description, be confused with those of Triænodes. In Triænodes the case is much smaller and more flexible. Its spiral is more plainly apparent than the spiral of Phryganea, and the leaf fragments are much narrower —in most examples almost thread-like.

KEY TO THE SPECIES OF PHRYGANEA.

A. Frons without dark markings.—*P. vestita.*

A.A. Frons with a median mark.

B. Median mark extending the entire length of the frons. Dorsal surface of the prothorax margined in front and behind with dark. No conspicuous dark markings on meso- and meta-thorax.—*P. interrupta.*

B.B. Median dark mark not reaching the hind margin of the frons. Prothorax not margined in front and behind with dark, but with two converging dark marks. Meso- and meta-thorax with two nearly parallel longitudinal dark marks.—*P. cinerea.*

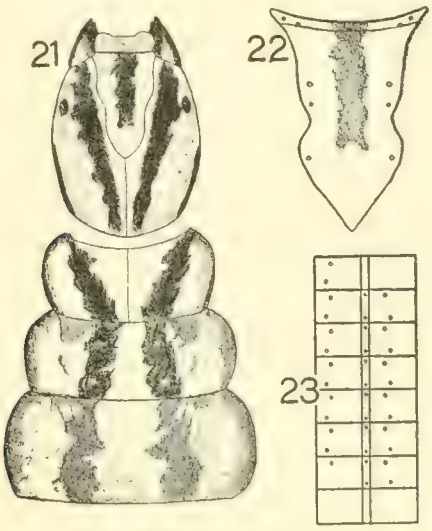
PHRYGANEA CINEREA.

HABITS.—This species is not known to me in life. The specimens from which the description is made were taken by Dr. C. Betten at Old Forge, New York.

Although none of the larvæ were reared, it seems probable that they are *P. cinerea,* for all known species of the genus, which might occur in this state, have been reared, except *P. cinerea* and *P. improba. Improba* is a very rare species, represented in collections by only a few specimens. Cinerea is more common and was taken at Old Forge by Dr. Betten during the season in which he collected the larvæ.

When collected, August 8th, one larva had spun the sieves across the openings of its case, indicating that its growth was complete and that it would have emerged about one month later.

DESCRIPTION OF THE LARVA.—The length of the larvæ is 17 mm., and the breadth at the third thoracic segment is 2.5 mm.



PHRYGANEA CINEREA.

21. Larva. Head and thorax.
22. Larva. Frons.
23. Larva. Distribution of gills.

Head.—Figure 21 shows the color pattern of the head. Its ground color is straw-yellow, marked as follows: A median mark begins on the front margin of the frons and extends back about three fourths of its length; a mark begins above the base of each mandible and extends diagonally back between the eye and the frons to the hind margin of the head; a line begins behind and below each eye and extends diagonally upward and backward to the hind margin of the head, where it meets the dorsal marks of the thorax; the under side of the head is without marking, except for a narrow margin of brown at the base of the mouth parts. The eyes are black.

The Thorax.—The prothorax is straw-yellow with dark marks which form continuations of the lateral marks of the head and converge toward the mid-dorsal line as they approach the hind margin of the segment; the epimera are dark-brown.

The meso- and meta-thorax are marked above with two almost parallel dark stripes which form continuations of the dark marks

on the prothorax and extend to the hind margin of the metathorax. Each epimeron is marked with dark-brown.

The legs are straw-yellow with a dark-brown mark on the front of each coxa.

The Abdomen.—The abdomen is marked on its upper surface with two parallel dark stripes, which form continuations of the thoracic markings. These marks are less conspicuous than those of the thorax and become fainter as they reach the caudal segments.

The gill arrangement is shown in figure 23. The caudal gill is lacking from the ventral series and segment 8 is without gills.

Phryganea Interrupta.

Larval Habitat.—In the region of Ithaca larvæ of *P. interrupta* have been taken, together with those of *P. vestita* in Michigan Pond and in the pools about the University Biological Field Station. Vorhies, who reared this species at Madison, Wisconsin, found it common in several situations of standing water "where Elodea occurs." In our locality the species is found in some situations where no Elodea grows, and it seems to us improbable that the presence of Elodea has any influence on the distribution of the larvæ.

Larval Habits.—The activities of the larvæ, so far as known, are like those of *P. vestita.*

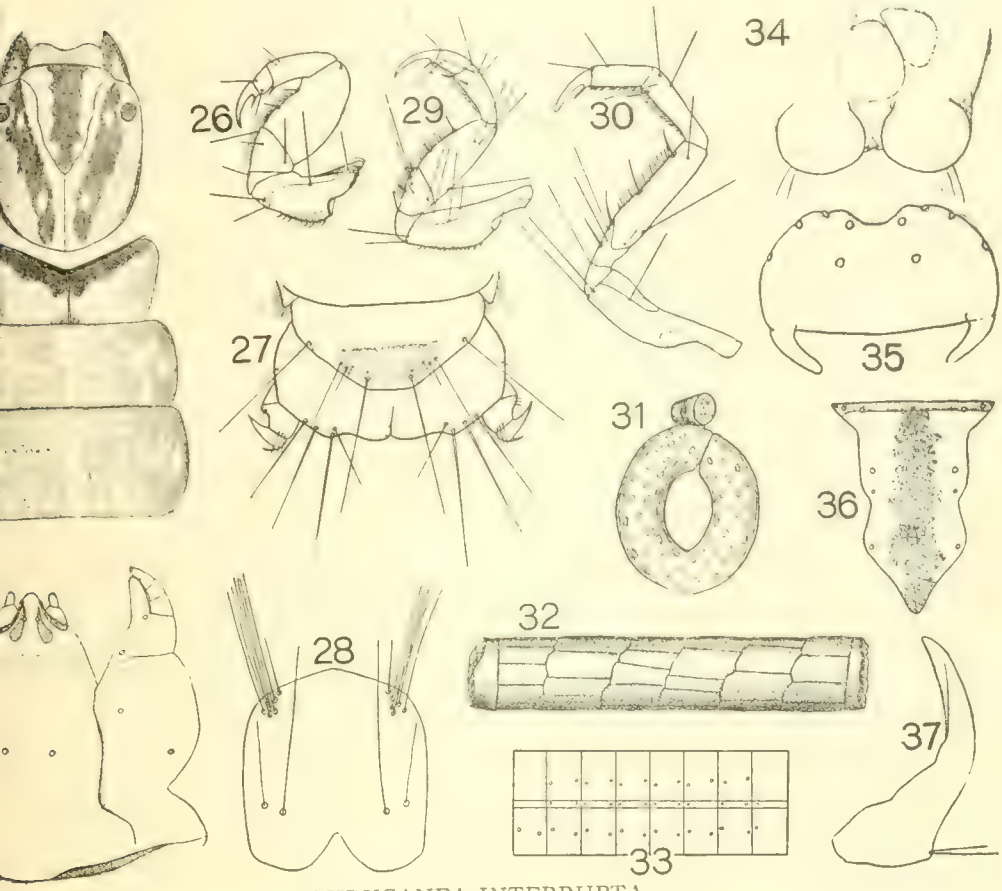
Although pupation takes place and the adults are on the wing together with those of *P. vestita,* the larvæ obtain their growth very much sooner than those of that species. By the first of January the larvæ of *P. interrupta* have obtained full growth, measuring thirty millimeters in length. At the same time the larvæ of *P. vestita,* from the same situation, measure only twelve to twenty millimeters in length.

In preparing to pupate, the habits of this species do not differ from those of *P. vestita.*

Period of Emerging.—Adults emerged from the last of May until the latter part of June.

Food of the Larvæ.—The stomachs of specimens examined contained about the same proportion of dead and green plant tissue found in the stomachs of *P. vestita.*

Vorhies speaks only of Elodea as food of the larvæ. No Elodea occurs in some of the situations of our region where the species is common. Probably Vorhies would have found his specimens feeding as readily on the leaves of other plants if opportunity had offered.



PHRYGANEA INTERRUPTA.

24. Larva. Head and thorax.
25. Larva. Lower mouthparts.
26. Larva. Front leg.
27. Larva. Caudal end of abdomen, dorsal.
28. Pupa. Labrum.
29. Larva. Middle leg.
30. Larva. Hind leg.
31. Egg mass.
32. Case of pupa.
33. Larva. Distribution of gills.
34. Pupa. Caudal end of abdomen, ventral side.
35. Larva. Labrum.
36. Larva. Frons.
37. Pupa. Mandible, lateral view.

DESCRIPTION OF THE LARVA.—Length, 30—35 mm.; breadth, 5 mm. The head and thorax are considerably broader and flatter than those of *P. vestita.*

Head.—The ground color is light straw-yellow. A dark-brown mark begins at the front margin of the head behind each mandible and extends obliquely back, paralleling the side of the frons, to the hind margin of the head, where it almost touches the mid-dorsal line. A dark-brown mark begins a short distance behind and below each eye and extends back to the hind margin of the head. The eyes are narrowly bordered with white. The frons is traversed from the front to the hind margins by a dark-brown median mark with irregular margins (figure 36).

The mandibles are dark-brown and black, except a somewhat triangular mark on the outer margin, which is paler; other parts of the head are straw color.

The Thorax.—Straw-yellow, marked on its upper surface with brown, as shown in figure 24. The pronotum is margined in front by a narrow line of very dark brown; behind this line there is a brown mark, on its hind margin there are similar but narrower markings of brown which, in the normal position of the larvæ, are covered by the metathorax.

The meso- and meta-thorax are light-green in life, with fine colorless markings, which are subject to considerable variation in pattern.

The supra-coxal plates are dark-brown, margined with black.

The legs are straw-yellow with narrow black marks on the outer edges of the bases of the coxæ, and shadings of light-brown on the margins. The outer surfaces of the coxæ of the first and second pairs of legs are thickly set with minute thorns, plainly visible only in prepared mounts, but much larger than those of *P. vestita,* in which species the thorns are visible only with the compound microscope.

DESCRIPTION OF THE PUPÆ.—Only cast pupal skins are in our collection. Vorhies states: "Length, 25—28 mm.; width, 6 mm. Antennæ extending to the sixth segment. Body in life, green; a fuscous band extending along the dorsal wall of the abdomen on either side."

Our cast skins show the following characters: The mandibles (figure 37) are almost twice as long as the labrum. The lateral

fringe is dense and black. The anal appendages (figure 34) are short.

Description of the Eggs.—The eggs have been found by Vorhies, who states: "An egg mass taken from vegetation in the water of Lake Wingra on July 21 proved to be of this species. It consisted of a cylindrical mass of clear jelly 6 mm. in diameter, in which the eggs were imbedded; the ends of this mass were bent around and united so as to form a perfect circle, with a diameter of 3 cm."

Figure 31 represents an egg mass of an undetermined species of this genus which was collected in a pond at North Fairhaven, New York.

Phryganea Vestita.

Habitat.—The larvæ have thus far been found in only two localities—Michigan Pond and the pools about the Cornell Biological Field Station. In these localities they are not uncommon.

Larval Habits.—From late summer until early spring the larvæ spend an active life on submerged vegetation. Rarely they are found crawling on the bottom.

In early spring, when time for pupation draws near, the larvæ seek the protection of some soggy submerged stick or log. Into this wood they slowly bore, dragging their cases with them, until they are completely beneath the surface—sometimes several inches beneath the surface. The work of boring is accomplished very slowly. The only larva observed during the process was found in the Field Station pools. When discovered, this larva had bored about one-half inch into a piece of soaked wood. The front end of the case was fastened firmly within the hole, and the hind end protruded from the surface at right angles. From day to day it drew farther into the wood until, at the end of a week, only the tip of the case remained protruding. During the operation the chunk was left in the pool where found. No dust or fragments of wood accumulated about the larva, and it was not known whether the waste was torn loose and extruded between the larva and its case, or whether it passed through the larva's alimentary tract. The larva's case fit so snugly in the hole that nothing could have passed outside it.

All pupæ found were beneath the surface of wood, usually in

holes which they had evidently made for themselves, though sometimes they were in cracks or between the bark and the wood. The front ends of the cases were fastened tightly, sometimes so tightly that pressure broke them before pulling them loose from their support.

Food of the Larvæ.—Stomachs examined contained almost entirely green leaves of aquatic plants. Only a few contained dead vegetation, but the choice undoubtedly was due to the environment of feeding, rather than to any choice of the larvæ.

Period of Emerging.—Specimens emerged June 10 to 20. Emergence was not observed, but the similarity of Phryganea pupæ to those of Neuronia in habitat, habits, and structure indicates that emergence is accomplished as in that genus.

Description of the Larva.—Length, 25—30 mm.; breadth, 3.5 mm. In life the color of the chitinous parts is pale straw-yellow with dark-brown markings.

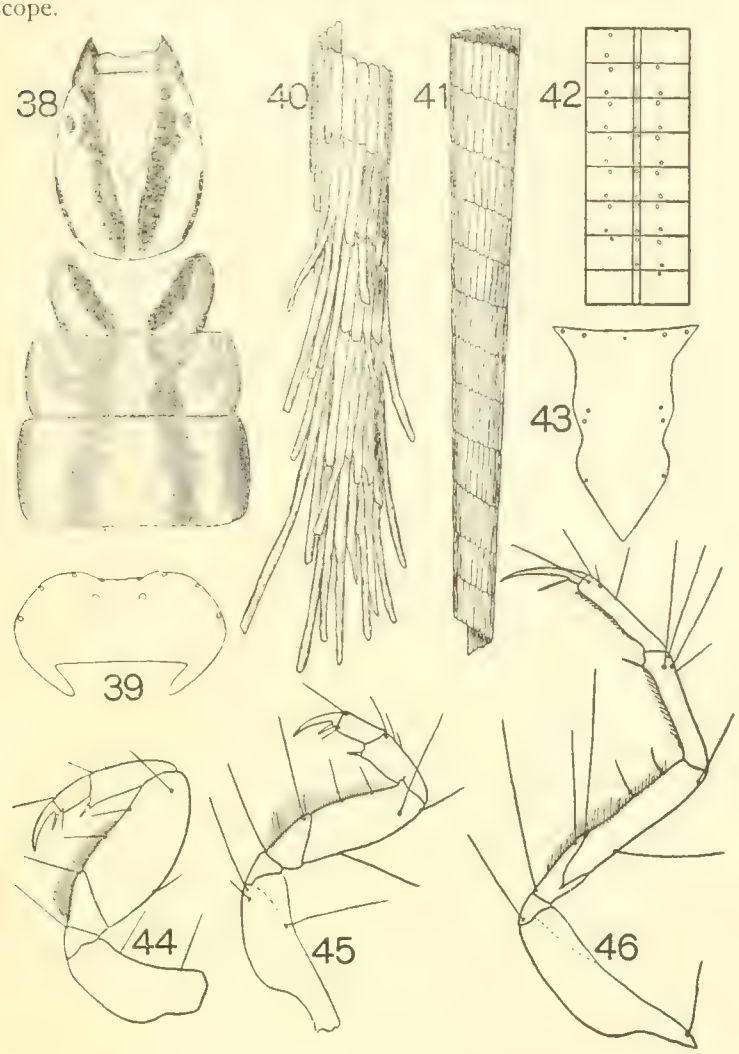
Head.—The color pattern of the upper surface of the head is shown in figure 38; its ground color is straw-yellow, lighter around the eyes; a dark-brown mark extends back from the base of each mandible, touching the margin of the frons, and passing on to the hind margin of the head; on the sides of the head an oblique dark mark begins behind each eye and extends back to the hind margin of the segment, paralleling the dorsal dark mark. The eyes are jet black. The frons (figure 43) is straw-yellow without markings, but is slightly darker than the ground color of the head. The mandibles are stout; the left mandible has three teeth above and three below, while the right mandible has but two teeth above and two below.

The Thorax.—The prothorax is straw-yellow with two oblique dark-brown marks, forming continuations of the lateral marks of the head, on its upper surface. The posterior sclerites of the propleura are dark-brown, margined with black on their caudal and lower margins.

The meso- and meta-thorax are brownish green in life, marked somewhat as shown in figure 38; the markings of these segments vary somewhat in different specimens.

The legs are straw color with dark-brown markings on each coxa and a mark of lighter brown along the back of the front femur. The legs are more slender than those of *P. interrupta,* and

the thorns on the first and second coxæ are much more minute—invisible except in prepared mounts under the compound microscope.



PHRYGANEA VESTITA.

38. Larva. Head and thorax.
39. Larva. Labrum.
40. Case of young larva.
41. Case of old larva.
42. Larva. Distribution of gills.
43. Larva. Frons.
44. Larva. Front leg.
45. Larva. Middle leg.
46. Larva. Hind leg.

DESCRIPTION OF THE CASE.—The case is tubular, tapering gradually from front to rear, and is not curved (figure 41). It is made of narrow, somewhat quadrangular, bits of leaves arranged in spiral form, wound from right to left. Different cases vary considerably in size, but usually they are about 5 cm. long, 5 mm. wide at the front, and 3 mm. wide at the hind end. The spiral usually has from 10 to 12 turns.

The case of the pupa is about 36 mm. long and has little or no taper. It is sealed at both ends with a sieve of silk.

FAMILY LIMNOPHILIDÆ.

HABITAT.—Limnophilid larvæ are fitted for life in almost every aquatic situation. In pond and slow-moving streams, especially those that dry completely during the drought of summer, their numbers far outnumber all other Trichoptera together. As the water becomes more swift the number of species becomes less, until in the swiftest water, in which loose stones come to rest, one finds only species of the genus Neophylax, but these often in great numbers. They are absent from the brinks of falls and from the parts of streams where the waters rush over bare bedrock.

Apparently in direct relation to the kind of water inhabited the development of gills has taken place. In those species that inhabit standing water the gills are large and numerous—often many-branched. In species of faster moving water the gill surface is noticeably less, and in Neophylax—the Limnophilid of the rapids—the gills are few and are reduced until hardly more than thread-like rudiments.

To this family belongs the European Enoicyla, which has the only terrestrial larvæ known to occur in the order Trichoptera.

LARVAL HABITS.—Little can be said that will cover the habits of all of the Limnophilid larvæ. The habits of each species are discussed separately on the following pages.

In preparing for pupation the larvæ retire to some secluded spot where there is little danger of molestation during the quiescent pupal period. One species at least, *Limnophilus indivisus,* buries itself among the submerged roots of sedges; more often the larvæ hide in the crevices of sticks or stones. So far as we know, only the larvæ of Neophylax remain in the open. These larvæ attach

their tough stone cases to the edges of rocks in swift water, without search for protecting crevices.

In this family, with the exception of the genus Neophylax, we have noted no attempt at gregarious grouping, except when accident brings the larvæ together. In Neophylax there is an unmistakable gregarious instinct developed when the prepupal period approaches. At this time larvæ gather in compact masses on certain parts of certain stones, while other similar stones in the same part of the stream remain uninhabited.

Food of Larvæ.—It seems probable that the larvæ are altogether herbivorous when living under natural conditions, but in the confines of aquaria they will often become carnivorous, or even cannibalistic.

The vegetation eaten by most species consists of vascular plants, living or dead, with more consideration for the convenience of the larvæ than for the condition of the food.

A few species, such as *Limnophilus submonilifer,* rasp the soft outer portions from submerged sticks and stems, and thus procure a diet that is often a mixture of higher plant tissue and diatoms—sometimes it is almost altogether diatomaceous ooze.

Period of Emerging.—From the time when Platyphylax begins to emerge, while the first warm spring sun still shines on the snow of late winter, until Neophylax and a few others cease their flight in the snow of early winter, there is no period without some species of Limnophilid.

Though on the wing from the snows of spring till the snows of fall, the adults are found in maximum numbers of species during late spring or early summer. In June, for a short time only, the greatest number of species are in flight, but there are other species for every period of the summer, and a few, such as *Limnophilus submonilifer,* continue to emerge during the greater part of the summer. Such species do not have a definite season when all the individuals occur as larvæ, pupæ, or adults, but can be found in all stages during most of the summer.

Description of Larvæ.—In form the larvæ are cylindrical. The head fits well into the first thoracic segment and is carried pointing downward at a decided angle to the rest of the body. The

first and second thoracic segments are chitinized dorsally, and the third segment bears three pairs of chitinous plates.

The Head.—The head is generally oval, sometimes decidedly tapering toward the mouth parts. The gula is triangular or elongate, and the epicrania are contiguous, or nearly so, behind its base. The labrum is broader than long, variously armed with bristles and hairs. The mandibles are stout, with blunt rounded teeth, and a pair of setæ on the outer surface and a brush on the inner surface.

The Thorax.—The dorsal surface of segments 1 and 2 is completely covered by chitinous shields. On the ventral surface of the prothorax there is usually a slender curved "horn" directed forward between the bases of the forelegs. The metathorax is soft, except for three pairs of chitinous plates; of these the lateral pair is somewhat crescentric in form and occurs slightly above the bases of the metathoracic legs; the median pair is small and somewhat oval or triangular, and is located near the cephalic margin of the segment; the second pair is small and of varying form, and is located more laterally and posteriorly than the median pair.

The Abdomen.—The abdomen is cylindrical in cross-section and of nearly uniform diameter throughout its length. Its first segment is provided with three more or less perfectly developed "spacing-humps" or callous spots. Gills are always present, but vary greatly in number and arrangement; they occur on the first segment, so far as known, only in an unidentified species of the genus Limnophilus. The lateral fringe is present, but is sometimes very feeble. The last segment bears a chitinous plate on the dorsal surface. The first segments of the prolegs are fused to form an apparent tenth segment.

Description of the Case.—The larvæ of the various genera of the Limnophilidæ make cases of great variety of form, and of almost every obtainable material.

In spite of their great variety of form and material the cases can, with a few exceptions, be readily determined by an observer with a little experience.

To this family belong the log-cabin type of cases; the cylindrical cases with little or no taper, made of rough fragments of bark, or sticks, or leaves, shells, or seeds; the cylindrical cases with heavy ballast sticks at the sides; also cases made of leaf fragments

that are triangular in cross-section; and flat, two-sided cases of leaf fragments.

All members of the family are makers of portable cases, but, so far as known, there are no spiral cases, and none made of a series of rings placed end to end; there are no cases that are four-sided in cross-section, and none that are made entirely of silk.

In the genus Neophylax the larvæ make cases of sand with large ballast stones at the sides, which are very similar to cases made by some of the Sericostomatidæ, but are more slender, smaller, and made of lighter material. A few genera (only Platyphylax as yet described from America) make curved, tapering cases of sand grains that quite closely resemble the cases of certain Leptoceridæ. Though there are fairly constant characters for determining the cases of the family, it is impossible to give characters for separating all of the cases generically or specifically. Often the cases of different individuals of a single species differ more widely from each other than from cases of species of widely different genera.

Limnophilidæ with gills arising in tufts of two or more. A dark colored longitudinal line on frons.

Name	Color Pattern on Frons	Lateral Margins of Dark Mark on Frons	Prothorax
Glyphotaelius hostilis	Black longitudinal mark	Parallel, not widening to include lateral setæ of front row	Light, except dark brown on front and hind margins, and median furrow
Limnophilus rhombicus	Brown longitudinal mark, usually forked at anterior end	Not parallel, widening toward front to include lateral setæ of front row	Mottled with brown without distinct light colored band behind median furrow
Halesus indistinctus	Black longitudinal mark	Not parallel, widening toward front to include lateral setæ of front row	Solid brown-black along front margin. A broad light band behind transverse furrow
Limnophilus indivisus	Black longitudinal mark. Sometimes forked at anterior end.	Not parallel, widening toward front to include lateral setæ of front row	Solid brown-black along front margin. A broad light band behind transverse furrow

(*Tables continued on page 42.*)

LIMNOPHILIDÆ WITH GILLS ARISING SINGLY.

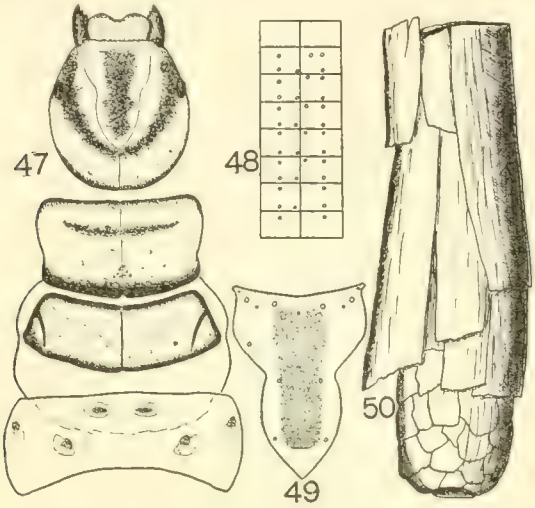
NAME	BROWN MARKS ON FRONS	PROTHORACIC HORN	EACH SIDE OF MESOTHRACIC SHIELD	SPACING HUMPS	VENTRAL SURFACE OF FIRST ABDOMINAL SEGMENT
NEOPHYLAX CONCINNUS	Muscle-attachment marks only	Absent	Margins only deep black	All present	With pair of thumb-like projections
NEOPHYLAX AUTOMNUS	Muscle-attachment marks only	Absent	Margins only deep black	All present	Without projections
ARCTOECIA MEDIALIS	Muscle-attachment marks only	Present	Margins only deep black	Dorsal hump absent, lateral humps present	Without projections
ASTENOPHYLAX ARGUS	Mottling besides muscle attachment marks	Present	A deep black isolated spot in each outer caudal angle	All present	Without projections
HALESUS GUTTIFER	Mottling besides muscle-attachment marks	Present	Margins only deep black	All present, dorsal hump nipple-like	Without projections
PYCNOPSYCHE SCABRIPENNIS	Mottling besides muscle-attachment marks	Present	Margins only deep black	Flattened or slightly rounded, Dorsal hump not nipple-like	Without projections

Limnophilidæ with gills arising in tufts of two or more. Without dark colored longitudinal mark on frons.

NAME	COLOR PATTERN OF FRONS	SETÆ ON CAUDAL HALF OF 1ST ABDOMINAL SEGMENT, VENTRAL SIDE
PLATYPHYLAX DESIGNATUS	Entirely light, except few brown spots	Scattered, not arising in two clusters behind middle of segment
CHILOSTIGMA DIFFICILE	Uniformly brown	Scattered, not arising in two clusters behind middle of segment.
PLATYCENTROPUS MACULIPENNIS	Entirely black, except caudal margin and few brown spots	Gathered in two groups.
LIMNOPHILUS SUBMONILIFER	Light, except caudal margin and sparse brown mottlings.	Scattered, not arising in two clusters behind middle of segment.

Glyphotælius Hostilis.

Habitat.—Full-grown larvæ were not uncommon during the fall of 1919 in the cove and pools about the Field Station. During previous summers a few larvæ were taken in the same locality, but



GLYPHOTAELIUS HOSTILIS.

47. Larva. Head and thorax.
48. Larva. Distribution of gills.
49. Larva. Frons.
50. Case of larva.

never in sufficient quantities to work out the life history of the species. In the summer of 1919 the larvæ were found in great numbers in the ditches of the Swamp at North Spencer. Hitherto the species has never been recorded from New York State.

Habits.—The larvæ were found climbing on submerged vegetation and crawling over the bottom, together with *Phrygane vestita* and *P. interrupta*. Nothing is known of the larvæ during the first instars.

Period of Emerging.—A single specimen emerged in the laboratory on April 5.

Description of Larva.—Length. 30—35 mm.; breadth, 5 mm. In life the soft parts are green and the chitinous parts are pale-yellow and dark-brown or black.

The Head.—A black band commences at the base of each mandible, and, touching the upper margin of the eye, curved inward

to the point of the frons, where the two meet (figure 47); a black band encircles the hind margin of the head; the frons is marked with a longitudinal stripe (figure 49), and is margined in front with brown; the mandibles are black; otherwise the head is straw-yellow.

The Thorax.—The prothorax is completely margined with black, except a narrow space at the base of each coxa; there is a dark-brown mark in the shallow transverse furrow, and an ill-defined brown area in front of the black caudal margin; otherwise the prothorax is pale yellow. The dorsal plate of the mesothorax is pale yellow, more or less mottled with brown, and with a border of dark-brown or black; in some specimens a curved black line crosses each caudal corner of the plate. On the metathorax the chitinous plates are dark-brown, more or less nearly surrounded by a lighter border.

The Abdomen.—On the first segment the spacing-humps are well developed; a few setæ arise from a small dark spot on each side of the cephalic margin of the dorsal hump; on the ventral surface there is a mound-like elevation bearing a pair of chitinous spots from which several setæ arise; on the ventral surface of each segment, three to seven, there is an oval chitinous disc, and on the eighth segment there is a pair of smaller discs; the gills are unusually broad and long, from one to three or four filaments arising from a single stem, but the number of filaments, and even the number of gills, is subject to very great variation in this species; figure 48 diagrams the distribution of gills for an average specimen.

Description of the Case.—In length the cases of mature larvæ are from 3.5 mm. to 5 mm. They are made of irregularly-shaped sections of leaves, as shown in figure 50; at the caudal end of the case the ends of the leaves are drawn abruptly in, leaving a round hole considerably smaller than the diameter of the tube.

Limnophilus Combinatus.

Habitat.—The larvæ are common in the slow-moving streams of Michigan Hollow, McLean marshes, and other upland localities.

Habits.—During their early life the larvæ frequent the grass and sedges which fringe the edges of the streams. As the time for pupation draws near they wander from the edges where marsh

grass abounds, to the middle of the stream where living vegetation is entirely absent. Here they attach the front ends of their cases firmly to some solid support, as a stick or stone. Often many of these pupæ are found congregated on a single small stick, while on the other sticks in the region they are entirely absent.

Food of the Larvæ.—The food consists, apparently, entirely of vegetable matter. Several stomachs from specimens taken at different periods of late spring and early summer were examined. These contained only the tissue of higher plants, but it seems probable that during the cold weather, when diatoms abound, these may compose a considerable portion of the diet of this species.

Period of Emerging.—This species is one of a few Trichoptera known to us which emerge during a long period. On May 22 there were pupæ in the stream, but no empty cases were found. On June 7 the first specimens in captivity emerged, but at that time there were many empty cases in the stream. From June 7 until July 22, when the last captive specimen emerged, their transformations in the cages were of almost daily occurrence. On the latter date, however, there were still many pupæ in the stream, and also a few prepupæ. From this data we may assume that the species is on the wing from early June until the middle of August.

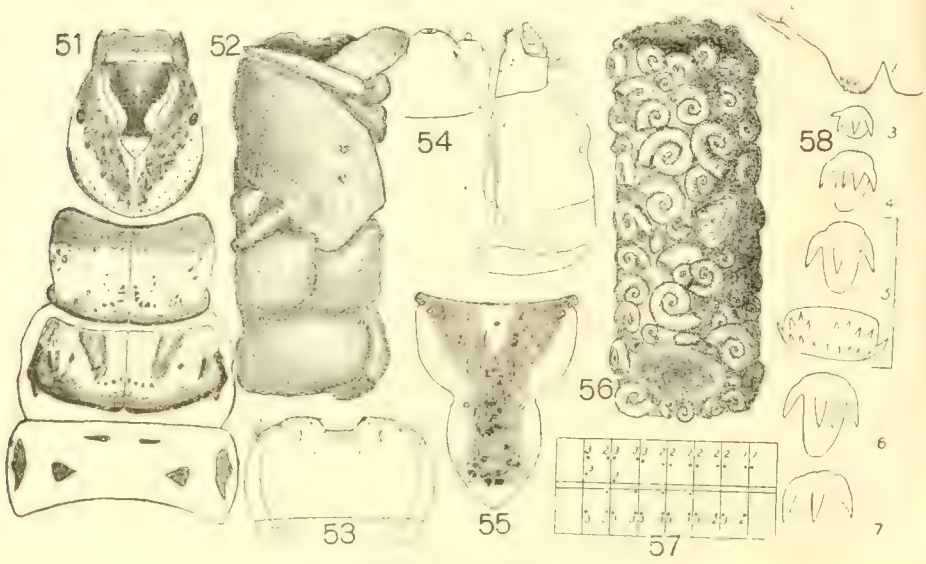
Description of Larva.—Length, when mature, 17—20 mm.; breadth, about 4.5 mm.

Head.—The dorsal markings are shown in figure 51; on the sides the head is light-brown mottled with dark-brown or black in the region behind the eye; the venter is light-brown in front, becoming darker toward the hind margin. The labrum is shown in figure 53; the frons in figure 55, and the labium and maxillæ, in part, in figure 54.

The Thorax.—The dorsal markings are shown in figure 51; on the sides, above each coxa, there is a dark chitinous plate bearing a group of setæ near its front margin; the venter is uniform in color. The "horn" on the ventral side of the prothorax is slender and evenly curved forward. The legs are dark-brown, margined and mottled with dark-brown and black.

The Abdomen.—The first segment is darker in color than the succeeding segments; it is armed with a few setæ in the region of the humps and on its ventral surface; segments two to seven bear

a few minute setæ; segment eight is bordered along its hind dorsal region by a dark area which bears a row of about six setæ; segment nine curves sharply downward and is darker in color than segments two to eight; it bears a dorsal chitinous plate which is



LIMNOPHILUS COMBINATUS.

51. Larva. Head and thorax.
52. Case.
53. Larva. Labrum.
54. Larva. Lower mouthparts.
55. Larva. Frons.
56. Case.
57. Larva. Distribution of gills.
58. Pupa. Chitinous plates of left side of abdomen.

armed with four large and several smaller setæ; there are also several strong setæ in the region of the drag-hooks; on the under side of each segment, two to seven, there is a narrow hair-like mark, oval in shape; the lateral fringe is short and black. The distribution and number of gills on the left side of the body are indicated diagrammatically in figure 57.

DESCRIPTION OF THE PUPA.—Length, 20—22 mm.; breadth, about 5 mm. The antennæ extend back to about the hind margin of the seventh segment; on the dorsal surface of the head, between the antennæ, there is a pair of strong setæ, and on the front surface, midway between the dorsal setæ and the labrum, there is a pair of similar setæ; each lobe of the labrum bears a group of stout

setæ which are curved, but not hooked, at their tips. On the second and third pairs of legs the swimming hairs are well developed. The lateral fringe is thick and black; the projections of the last segment are much as in *L. indivisus* (figure 64). The dorsal surface of the first abdominal segment and the chitinous plates (the latter subject to variation in the number of teeth) are shown (left side only) in figure 58.

THE CASE.—Length, 20—25 mm.; the breadth varies greatly according to the material used in construction. The young larvæ, before they leave the grass on the stream's edge, make a case of the cross-stick type common in this genus. When, as the time for pupation draws near, they migrate away from the grassy area, their cases take on an entirely different appearance, being constructed of shells, or small chunks of bark, or seeds, from the bottom. In the meadow area at Michigan Hollow the building material used, after their migration from the shore line, consisted almost entirely of the shells of water snails—*Planorbis* and *Sphærium*, for the most part—and of oval seeds. Figure 56 shows a case from this area. Higher up in the same stream, where the waters are overhung with thickets, the larvæ use chunks of bark in the construction of their cases (figure 52). Different combinations of these materials are frequently found, and sometimes cases are encountered in which the front part is made of shells or chunks, while the hind part retains the cross-stick construction used in its previous environment.

LIMNOPHILUS INDIVISUS.

HABITAT.—Upland pools or ponds which are rich in decaying vegetation and are subject to desiccation during the middle or latter part of summer.

In waters which it inhabits this species is found in extraordinary numbers, its cases almost covering the bottom of the pond during the late larval period.

HABITS.—During the period when water covers their habitat the larvæ can be found clumsily drawing their bulky cases over the bottom of the pond or climbing over the vegetation. Their activity, apparently, does not cease during the winter months.

Early in May, close examination of a pond where the larvæ had been found in great abundance, covering the bottom with an

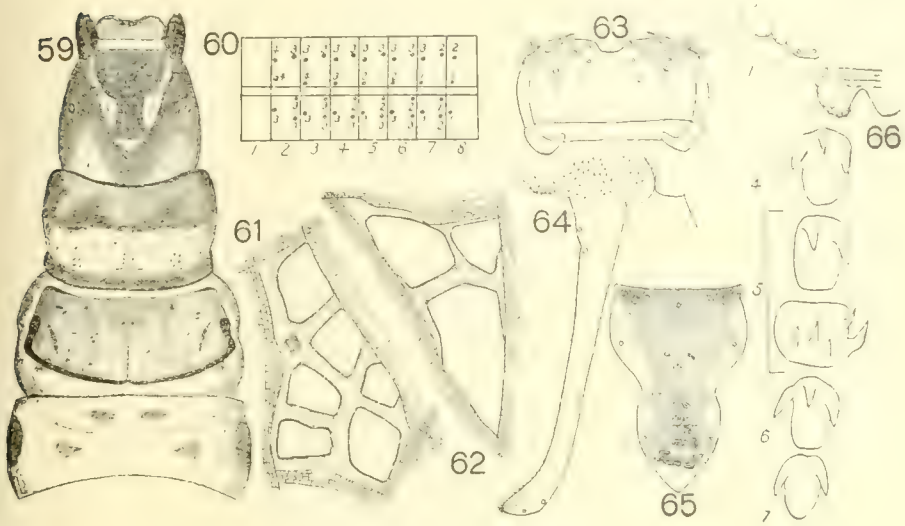
almost unbroken mass of moving cases, at first revealed not one inhabited larval or pupal case. They were not on the bottom, nor were they clinging to the vegetation, as is the habit of some species of the genus when pupating, nor were they under sticks or logs, nor in crevices. At last they were found deep down among the fibrous roots of sedge tussocks. Here they occurred in such numbers that they could be brought out by the handful from every tussock. Well hidden, as they were, their hiding places had been found by the muskrats of the region. Stumps and floating logs were piled by the rats with broken pupal cases from which the contents had been removed. Muskrat feces taken from these locations and disintegrated in water revealed enough chitinous fragments to indicate that the caddis-pupæ were an important article of diet at this season.

On emerging, the pupæ come to the surface and swim about, apparently blindly, until they encounter some suitable support projecting above the water, where, climbing a few inches above the surface, they transform. The greatest number of adults were on the wing during the middle of May. At this time swarms of them clung to every near-by bush, or, as dusk changed to darkness, flew over the pond.

Food of the Larvæ.—The larvæ eat vegetable matter, living or dead, with little discrimination for species or condition of preservation. They may readily be seen browsing on dead and decaying cat-tail or sedge, or on living plant tissue, or scraping loose fibers from submerged sticks. The stomachs examined contained particles of higher plant tissue in all stages of preservation, as well as many algæ, but decaying tissue was always in greatest abundance. The dominance of decaying tissue in the stomachs may be explained by a glance at their habitat during spring, before the period of pupation. At this time the pools are full of dead and decaying cat-tails and sedges; living plants are relatively rare. The algæ are apparently swallowed accidentally with the larger plants over which, in these pools, they form a thick scum.

Description of the Larva.—Length, when mature, 18—21 mm.; breadth, 3.5—4.5 mm. The color of the heavily chitinized parts is brown; the abdomen and weakly chitinized parts are white in young specimens, and rusty brown in individuals that are almost ready to pupate. The rust-like appearance of the weakly chitinized

parts of this larva is caused by a coating which can, with difficulty, be removed, leaving the skin white and revealing a sparse armature of very minute spines. The distribution of this rust-like coating



LIMNOPHILUS INDIVISUS.

59. Larva. Head and thorax.
60. Larva. Distribution of gills.
61. Sieve net. Front end of pupal case.
62. Sieve net. Caudal end of pupal case.
63. Larva. Labrum.
64. Pupa. Caudal appendage.
65. Larva. Frons.
66. Pupa. Chitinous plates of left side of abdomen.

is nearly uniform in different individuals and seems to be a secretion from the skin.

Head.—Marked above as in figure 59; the sides are light-brown without sharply defined marks, but, on caudal portion, bearing many small, inconspicuous muscle-attachment spots; the ventral side is uniformly light-brown, except the extreme caudal portion, which is crossed by the area of dark spots extending downward from the sides; the antennæ are jet black, except an area at the base, which is brown; the labrum (figure 63), is light-brown bordered with dark-brown; the mandibles are jet black, truncate, with fine teeth and a rather sparse brush of light-colored hairs on the edge of the groove; of these hairs the most cephalic are shorter and thicker.

Thorax.—The dorsal markings are shown in figure 59. The prothorax bears minute forward-pointing spines on its cephalic dorsal margin; its setæ are long, some equal to the length of the segment; a raised, black collar-like ridge extends from the base of the legs over the dorsum of the caudal margin of the segment, except at the median area, where it is broken; the ventral surface is white, except a brown spot which bears two darker marks near its caudal margin, and a small darker spot behind each leg; the fleshy horn is curved and well developed. The mesothorax is white beneath, with four dark spots near the caudal margin. The metathorax is white on the under side, with two broken dark marks.

Legs.—Brown, with darker margins, and armed with numerous long black setæ.

Abdomen.—The humps are well developed; the dorsal hump bears a pointed, finger-like process, and the lateral humps are rounded; groups of setæ occur at the sides of the humps; about six large setæ and several small ones occur on the ventral surface of the first segment; other segments do not bear large setæ on their ventral surfaces; segments 2 to 7 bear single small setæ on each side of the medium line above; segment 8 bears a row of about ten setæ across its ventral surface; segment 9 has an oval chitinous plate on the dorsum, which bears four large and many small setæ; each drag-hook has three small teeth at its base and is preceded by a chitinous plate bearing about ten setæ; a row of three large setæ occurs inside of each drag-hook and behind the chitinous plate; the lateral fringe is black and well developed; it extends from near the cephalic margin of segment 3 to the caudal margin of segment 8; above the lateral fringe on each segment occur minute, brown, paired spine-like processes; the gills are well developed; their number and distribution are shown diagrammatically in figure 60. The weakly chitinized portions of the entire larva are thickly set with minute spines.

Description of the Pupa.—Length, 13—17 mm.; breadth, 4—4.5 mm. In life the color of the thorax and appendages is brown, the abdomen is green, and the lateral fringe is deep black. The antennæ extend back to about the caudal margin of the eighth segment; they bear groups of short setæ on the dorsal sides of the second segments; each side of the labrum bears a group of about six long, hooked setæ; a row of sharp, curved forward-

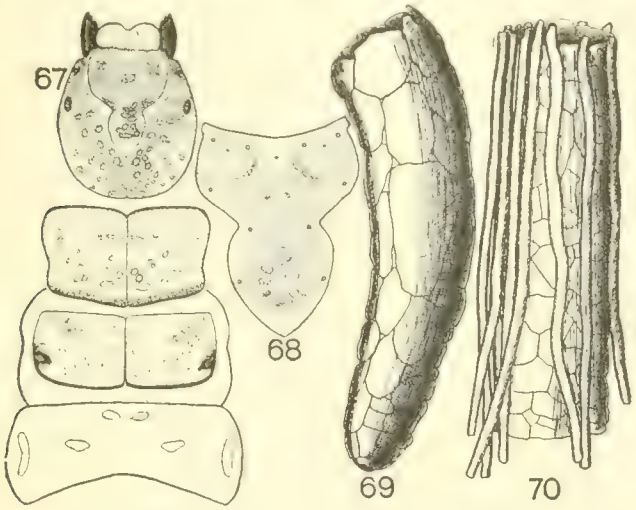
pointing spines borders the caudal margin of the eye; the second and third pairs of legs have well-developed swimming hairs and, in advanced pupæ, show the black spines of the adult conspicuously; the lateral fringe is well developed, commencing on the caudal margin of segment 5 and turning under the abdomen at the caudal margin of segment 8; the gills are well developed; the last segment bears a number of setæ and two backward-pointing processes (figure 64).

Description of the Case.—The length and breadth vary according to the material found in its environment. It is always bulky and is usually of the cross-stick type common in the genus. It may be made of bits of leaves or plant-stems or, sometimes, of seeds. When seeds are used it does not show the tendency to cross the material. The cavity is cylindrical and is always lined from end to end with a sheet of silk.

The case of the pupa differs from the larval case only in having the mesh of silk across its ends as illustrated in figures 61, 62.

Limnophilus Submonilifer.

Habitat.—The larvæ are found in shallow water where there is an abundance of vegetation, often in situations that are com-



LIMNOPHILUS SUBMONILIFER.

67. Larva. Head and thorax.
68. Larva. Frons.
69. Case of mature larva.
70. Case of immature larva.

pletely dry during the droughts of summer. In the shallow edges of the Cove, in Bools' Backwater, and in most similar situations of the region, they are not uncommon dwellers.

HABITS.—Members of the species are bottom-crawlers, where their cases, closely resembling stems and grasses, are detected with no little difficulty.

Before pupating the larvæ wrap themselves securely, including their cases, in folds of the leaves of submerged plants or grasses. In this condition they are so perfectly concealed that their detection requires careful examination of every grass-blade.

FOOD OF LARVÆ.—Raspings from submerged sticks and plants form the food of the larvæ. In the raspings are found diatoms and other microscopic organisms, as well as wood and plant fragments.

If one watches a larva feeding upon a diatom-covered stick he will plainly see a trail of clean wood left behind the slowly moving larva.

DESCRIPTION OF THE LARVÆ.—Length, 15 mm.; breadth, 2.5 mm. The chitinous parts are light-brown, with a darker pattern of slight contrast, as shown in figure 67. Details of marking are subject to some variation in different specimens, but there is enough uniformity of pattern to make color characters of value in classification.

Head.—An ill-defined area of brown begins at the base of each mandible and extends back, adjacent or close to the margin of the frons and above the eye, to the caudal margin of the head; when this mark does not touch the frons, the area between it and the frons is almost colorless; each eye is located on the upper cephalic side of a light-colored circle; behind the eye the entire head is more or less marked with muscle-attachment spots; in front of this area the under surface is uniform brown. The frons (figure 68) is brown, with a light mark of varying size extending back from the median part of the cephalic margin, and a light-colored area behind the muscle-attachments spots; in some specimens the margins behind the constrictions are light-colored; the muscle-attachment spots are dark, but not strongly contrasting in color.

Thorax.—The prothorax is light-brown, margined with dark-brown or black, and with varying marks of brown (figure 67).

On the mesothorax the chitinous shield is pale-brown, with darker markings and black caudal margin terminating laterally in expanded black marks of varying extent; a broken dark mark is sometimes present on the cephalic margin. The chitinous plates of the metathorax are pale in color; the lateral plates are crossed by two dark marks.

The Abdomen.—On the ventral surface of the first segment there are a few weak setæ, which are not arranged in clusters. The gills are weak and are branched into a few weak filaments.

Description of the Case.—The case of the larva has the form of a cylinder about twenty millimeters long and four millimeters wide. It is made of vegetable matter of various kinds, according to the environment inhabited by the larva.

A common type of case is made of fragments of bark (figure 69). These cases generally curve slightly and taper toward the caudal end. The cephalic end is without a hood; the sides of the caudal end are drawn in to leave a small round opening.

When the larvæ live among cat-tails, or where large fragments are used, the curve of the case is less apparent, or may be entirely absent. Likewise the caudal end is less closed, or may be entirely open.

When living among roots, the larvæ often fasten root fibers along the sides of their cases (figure 70).

In preparing to pupate the larvæ roll their cases in dead leaves, or in grasses. At such times they are next to impossible to discover.

Arctœcia Consocia.

Larval Habitat.—The larvæ occur locally in most streams of the region. They are more common in shallow water with a slight current, but they are also found in deep waters that are cool and well aeriated.

Habits.—In their manner of living the larvæ do not differ greatly from *Pycnopsyche* and its near allies, and, like them, the habit of changing the architecture and material of their cases from one type to another is frequently practiced. When time for pupation approaches, the larvæ usually hunt the seclusion of matted roots along the water's edge, or crevices in submerged logs or bark.

On one occasion several pupæ were found attached to roots

two to four inches above the level of the water. The water below was a spring pool which never rises to the level to which the larvæ had climbed. These pupæ were put in cages with no water, and successfully emerged about ten days later.

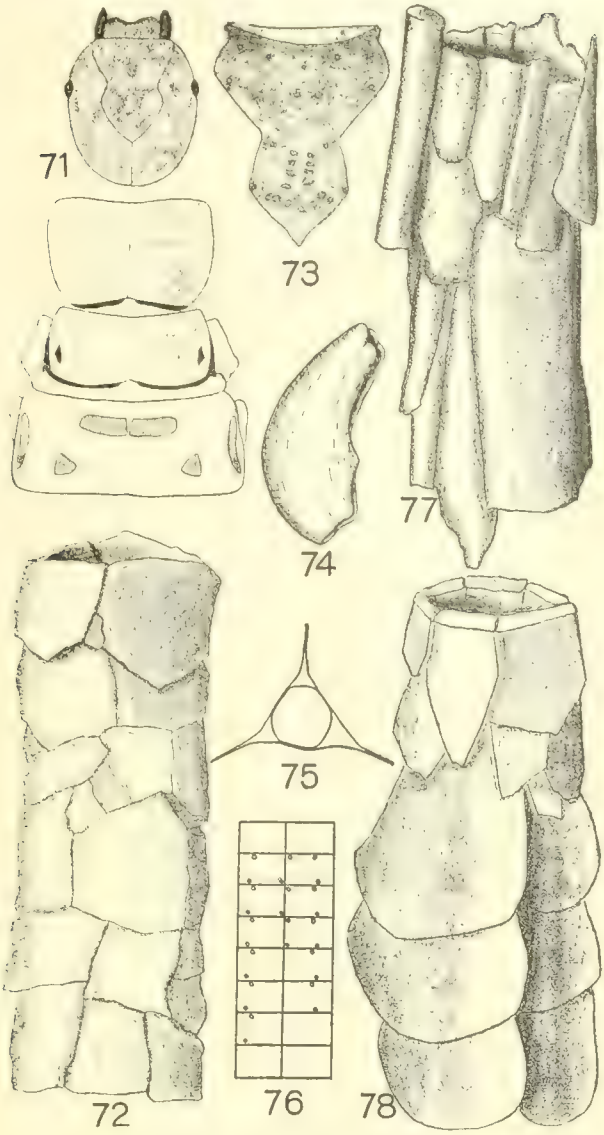
Food of Larvæ.—The larvæ feed on shallow raspings from the sticks and vegetation of the waters they inhabit. Stomachs examined contained a large amount of the outermost tissues of plants and sticks, together with about the same amount of sessile diatoms, and an occasional fragment of some minute crustacean, perhaps swallowed by accident.

Period of Emergence.—Specimens in captivity emerged during the latter part of June.

Description of Larva.—Length, 25 mm.; breadth, 4 mm. In attitude the larvæ maintain straight abdomens, slightly curved thorax, and head turned well under the first thoracic segment, with the mouth parts between the front legs. The coxæ are carried with their distal ends directed toward the median line of the body, which brings the bases of the tibiæ almost together.

The Head.—In color the head (figure 71) is light-brown, with very faint speckles of a shade darker over the dorsal and caudal portions; an unspotted area begins at the hind margins of the eyes and extends around the caudal portion of the ventral surface of the head. The setæ on the dorsal surface are deep-black. The frons is without pattern, except the faintly darker muscle-attachment spots. The mouth parts are often carried almost entirely telescoped within the cavity of the head; they have the general color of the head, except the mandibles, which are deep-black; in form the mandibles are broad and scoop-like, but slightly indented on the anterior margin.

The Thorax.—The prothorax has the dorsal furrow very feebly developed. In color the dorsal surface is pale straw-yellow with a few inconspicuous small specks of a slightly darker shade. The chitinous plate of the mesothorax is colored like the dorsal surface of the prothorax, its narrow caudal margin is conspicuously black, and there is a small, roughly triangular spot of black near each lateral margin, about midway between the front and hind margins. The deep-black coloring of the pleural suture is limited to a spot near the base of the coxa, and does not extend



ARCTOECIA CONSOCIA.

71. Larva. Head and thorax.
72. Case.
73. Larva. Frons.
74. Larva. Mandible.
75. Case. Cross section.
76. Larva. Distribution of gills.
77. Case.
78. Case.

back in a narrow line. On the metathorax the median chitinous plates are almost contiguous; the lateral plates are somewhat crescentric in form, and have a sparse growth of black setæ near the cephalic end.

The Abdomen.—On the first segment the dorsal hump is lacking; the lateral humps are well developed. The dorsal surface of the segment has a sparse growth of black setæ, which are not arranged in groups; the ventral surface of the segment bears a pair of light-colored chitinous plates, one each side of the median line behind the middle of the segment, each plate bearing a sparse line of short, dark-colored setæ along its cephalic margin; in front of these plates the cuticula bears a few irregularly placed setæ; at the base of each lateral hump, on the ventral side there is a pair of pale chitinous plates, the caudal plate the larger, each bearing a few setæ. The distribution of gills is represented in figure 76.

Description of the Case.—The species makes such a great variety of cases, of which different types so closely resemble the cases made by several other genera, that it is impossible to place any taxonomic importance on their architecture.

In a rough way the cases fall into two types—circular and triangular in cross section.

The triangular cases, made like the caudal part of figure 78, show the most distinct plan of architecture. From the exterior three sides are visible; each side is slightly convex, and is made of from three to six roughly oval sections of dead leaves. The cephalic end of each oval is fastened under the caudal end of the preceding oval. In cross section, figure 75, it is apparent that the outer triangle surrounds a thin-walled cylinder of leaf fragments, lined with silk.

In the cylinder type of case the larvæ sometimes make very neat structures of flat chips of stones, figure 72. In these cases the stone chips are neatly fitted and cemented together with a thin lining of silk. In cross section the cases are as nearly cylindrical as the size of the stones will permit. Besides these cases, which are built with a high degree of neatness, the larvæ sometimes make cases of twigs, fragments of bark, and debris of all sorts. These cases, of which figure 77 represents one of the most perfect, are among the most slovenly and carelessly-built cases inhabited by Limnophiladæ.

Astenophylax Argus.

Habitat.—In most of the slow-moving, alder-bordered streams of the uplands the species is uncommon, but in Michigan Stream to the South, and Argus and Sphærium Streams to the East, they occur in the greatest abundance. In Michigan Stream their numbers are astonishing for a species of such size. Many hundreds of individuals live on a single rod of the small creek's bottom, and scores of pupæ can often be found clinging to a single root or stick.

Habits.—As might be expected under the uniform conditions of the spring-fed upland streams, the larvæ alter their habits but little during the changing seasons. In winter, as in summer, they crawl actively over the bottom, feeding and carrying on their usual activities. In both seasons the stomachs are equally gorged.

By the middle of April the larvæ have ceased their activities and have gathered and attached to their cases bulky, heavy material, large pebbles, chunks of bark, the large species of Sphæriidæ, *Sphærium simile,* or twigs, sometimes inhabited by the wood-boring Trichoptera of the genus *Ganonema.* These heavy cases are attached firmly by their cephalic ends to submerged logs, roots, or other solid supports. At this time the sieve-nets are spun. In *Astenophylax argus* the sieves are located within the tube a short distance from its caudal and cephalic ends. The mesh varies in size and form, but is roughly hexagonal.

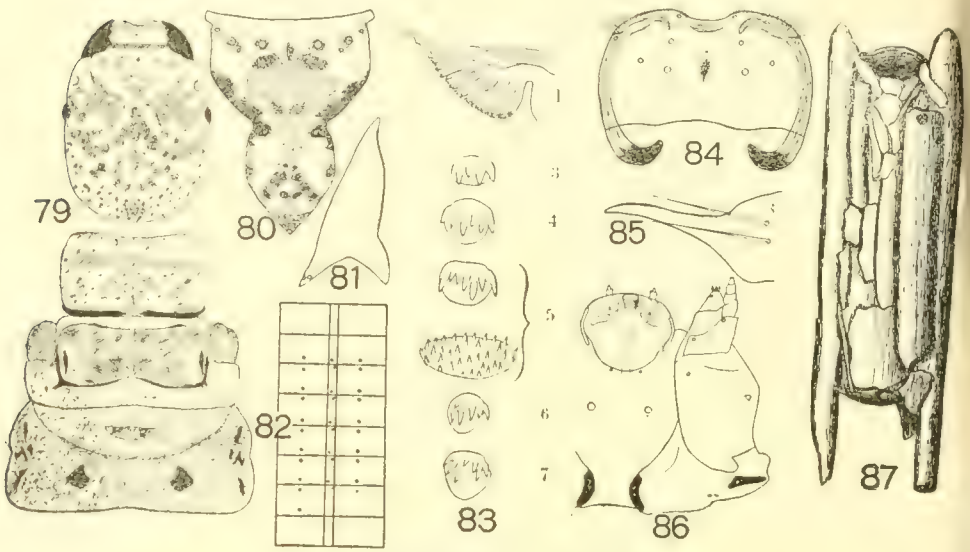
Food of the Larvæ.—The food of the larva throughout the year consists of dead bark and wood rasped from submerged twigs and logs. Specimens collected in February contained the same kind of food as specimens collected in mid-summer, and at both seasons the alimentary tracts were equally gorged.

Period of Emerging.—The time of emerging is confined to the first two weeks of June.

Description of the Larva.—Length of the mature larva is 50 mm. Its breadth at the third thoracic segment is 6 mm.

Head.—The head, except the mandibles, which are black, is brown, with inconspicuous darker markings, which vary somewhat in intensity in different individuals, but maintain the same general pattern for the species; the color-pattern and distribution

of setæ on the dorsum are shown in figure 79; the underside of the head lacks markings except an area of small, somewhat oval, well-defined spots, which project forward from its caudal margin on each side of the median line.



ASTENOPHYLAX ARGUS.

79. Larva. Head and thorax.
80. Larva. Frons.
81. Pupa. Mandible, lateral view.
82. Larva. Distribution of gills.
83. Pupa. Chitinous plates of left side of abdomen.
84. Larva. Labrum.
85. Pupa. Mandible, outer edge.
86. Larva. Lower mouthparts.
87. Case.

Thorax.—The color-pattern of the dorsum of the first and second segments is shown in figure 79; the under side is weakly chitinized, except for the horn on the first segment; the third segment above is weakly chitinized, except for a median glabrous spot near the cephalic margin, on each side of which there is a dark-brown mark, bearing five or six setæ; farther back and slightly more remote from the median line there is a triangular spot bearing about ten setæ; on each side of the segment there is an elongate glabrous area marked with several brown spots, the cephalic of which bears about a dozen setæ; the second and third thoracic segments bear numerous minute spines which, for the most part, point forward.

Legs.—Brown, with darker markings along the edges and around the setæ.

Abdomen.—The first segment above has several circular brown spots surrounding setæ, a glabrous area borders the caudal margin of each lateral hump, and a group of four or five fine setæ is present above and below each lateral hump; on the ventral side there are a few scattering setæ and a bilobed median mark, containing four or five setæ in each lobe; the entire surface of the first segment is thickly set with very minute spines. The lateral fringe of black hair begins near the posterior margin of the second segment and extends to the posterior margin of the eighth segment. The arrangement of gills is diagrammatically shown in figure 82. A slight variation of gills occurs on the caudal segments of different individuals.

Description of the Pupa.—Length, 30 mm.; breadth, 6 mm. The labrum is longer than broad, extending shelf-like over the mandibles and bearing a group of five long, dark-colored, hooked setæ on each side; two similar setæ, but not hooked occur on each side near the base, a shorter seta of lighter color points forward from the cephalic margin of each lobe and a similar seta occurs laterad from each pair of long basal setæ; the mandibles are straight, without teeth and sharply pointed, reaching not quite to the extreme of the labrum; each bears two setæ near its base; the dorsal part of the first abdominal segment is marked with small cross-folds, which give it a striate appearance, and is bordered behind with wing-shaped marks, somewhat striate and bearing numerous small thorns on their caudal margin, figure 83; the lateral fringe is black, commencing near the caudal margin of the fifth abdominal segment and forming a loop beneath the caudal margin of the eighth segment. The antennæ reach to the caudal margin of the sixth segment. The chitinous plates are shown in figure 83, but the number and arrangement of teeth is subject to variation in different individuals.

Description of the Case.—The larval cases, figure 87, the largest and most bulky in our streams, are constructed of fragments of twigs and bark, which vary greatly in size and shape. These fragments, arranged with little regard for system or symmetry, are fastened securely together by means of silk, and the

tube thus formed is lined from end to end with a tough cylinder of silk. Clumsy and bulky as the larval cases are, they do not vary greatly from cylindric form, nor do they have projecting twigs or corners that would catch during locomotion, nor chunks or stones that would be too heavy for the powerful larvæ to drag. In the pupal cases heavy stones and great fragments of bark are used, whose weight and form would make locomotion almost impossible.

Pycnopsyche Scabripennis.

Habitat.—Specimens of this species were collected only in Sphærium and Argus Brooks; but the larvæ and cases are so similar to Halesus, and probably to other genera, that it is by no means probable that its distribution is as restricted as our data would indicate.

Habits.—In the streams mentioned the larvæ are exceedingly abundant, crawling slowly over the bottom, or clinging with their heads pointing upstream, to submerged sticks and logs. In the latter position they sometimes completely cover sticks which are slightly above the stream's bottom, but upon the slightest jar they relinquish their holds and float down with the current.

Before pupation the larvæ leave the open water and hunt the seclusion of crevices in bark or root mats. At this time casual examination of the stream reveals not one larva in localities in which thousands previously formed the most conspicuous life on the bottom.

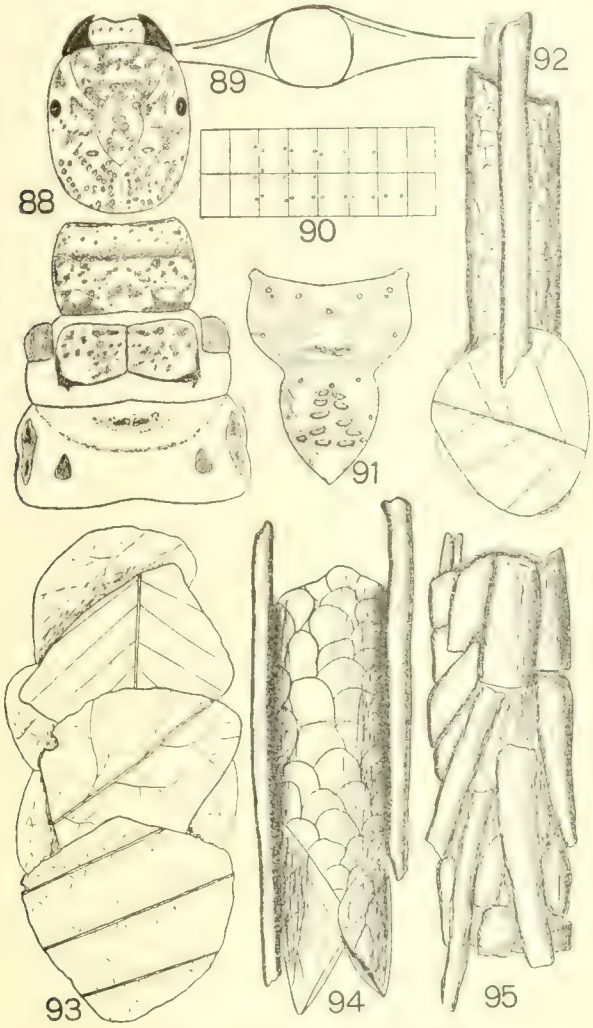
Food of Larvæ.—Stomachs examined contained only raspings of decomposed wood, much of which was ground to fine powder.

Period of Emerging.—Adults appear during the last days of August and the first part of September.

Description of Larvæ.—Length, 25 mm.; breadth, 3.5 mm.

Head.—The head, figure 88, is large; in dorsal view it has almost parallel sides, slightly curved caudal margin and almost straight cephalic margin; in color it is straw-yellow, with a varying pattern of round or oval muscle-attachment marks, and shadings of dark-brown; on the ventral surface the brown muscle-attachment marks are confined to the caudal half of the head and

are bounded on each side in front by an oblique line of black muscle-attachment marks; between the oblique line of black attachment marks and the mouth parts there is shading of black and brown.



PYCNOPSYCHE SCABRIPENNIS.

88. Larva. Head and thorax.
89. Case. Cross section.
90. Larva. Distribution of gills.
91. Larva. Frons.
92. Case.
93. Case.
94. Case.
95.. Case.

The labrum is small, and about half the breadth of the cephalic margin of the frons.

Thorax.—The prothorax, figure 88, on its dorsal surface, has ground color of straw-yellow, slightly lighter than the head; it is shaded and mottled with dark-brown.

On the mesothorax the dorsal chitinous plates are mottled with dark-brown, except a circular area in each outer caudal angle, which is without mottling.

The metathorax has the median plates slightly separated, situated on a single plate-like area that is apparently more heavily chitinous than the surrounding integument of the segment. The plates of the second pair are uniform brown. The lateral plates are brown with dark marks at each end.

Abdomen.—On the first segment the spacing-humps appear as flat, brown, callous areas, which are but slightly raised above the surface of the segment; the cone-like form of the humps of *Halesus* is entirely absent. On the ventral surface, behind the middle of the segment, there is a pair of chitinous plates, each bearing about six setæ; in front of the middle of the segment there are a few scattered setæ.

The arrangement of gills is shown in figure 90.

Description of the Case.—The cases of *Pycnopsyche scabripennis* are subject to great variation in form. As a rule, the variation is seasonal—almost all of the cases are made on the same plan and undergo the same transitional change at the same time, but there are often a few specimens to be found that have omitted certain changes in their case-making. So one finds great numbers of specimens in a locality making cases of the same kind, but with careful search it may be possible to find examples of other types of architecture.

The first cases made by the species are usually flat, two-sided cases of leaf fragments, figure 93. In making this form of case the larva cuts round or oval fragments from sunken leaves. These pieces are cemented on the opposite sides of the cylinder in which the larva lives. At the cephalic end the upper leaf, or root, projects, hood-like, beyond the end of the tube; at the caudal end the roof covers the end of the tube, but the floor usually projects out even farther. Between the roof and the floor lies the tube in which the larva lives. It is made by cementing sides of small

leaf fragments between the broad floor and roof, and lining the cavity thus formed with a thin but tough sheet of silk. Figure 89 represents a cross-section of the case.

This type of case is used during the winter and spring months. It is the type most frequently omitted by the larvæ, perhaps because their environment does not always furnish suitable material.

Though the broad, flat form of these cases of leaf fragments, with their hoods projecting over the heads of the slowly-crawling larvæ, are as nearly invisible as is possible, it seems probable that their most important function is to form a broad surface that will always remain with the same side up, and not roll in the slow current.

As the larvæ get older, in late spring, they change the flat-leaf type of case to cases in which the tube is much tougher. Small fragments of bark are now mixed with pieces of leaves in the tube, the broad roof and floor of leaves is discontinued, and on each side of the case a heavy stick is added, which usually runs the entire length of the case and projects for half an inch beyond each end, figure 94. These "ballast" sticks have the same function as the flat surface of the leaf cases—they keep the cases from rolling in the current.

In changing the case from the flat-leaf type to the ballast-stick type, the sticks are added to the top and bottom of the leaf case, causing the sides of the leaf case to become the top and bottom of the ballast-stick case. Figures 92 and 94 represent the transition between the flatleaf case and the ballast-stick case.

When the time for pupation draws near the larvæ of Pycnopsyche, like several other species that use ballast sticks, cut away the ballasts and make rough cases of irregular construction, in which there is no difference between top and bottom, figure 95. When the case is made fast for pupation there is no longer need to make other provision against its rolling in the current.

Platyphylax Designata.

Habitat.—The larvæ are abundant in the Big Springs of the McLean basin, and occur in less abundance in several of the nearby springs and spring streams. All of the waters in which the larvæ have been found are cold throughout the summer and never freeze in winter. It was in similar springs in Wisconsin that Vorhies first found the larvæ.

Although, in the Cayuga Basin, the larvæ have been found only in the McLean region, careful collecting probably will reveal their presence elsewhere, for the adults are not uncommon in several localities of our uplands.

Habits.—During the daytime some larvæ can always be found crawling over the bare stones of the springs they inhabit. More larvæ, however, are to be found attached to the under-side of sticks and stones. These larvæ, like other species of Limnophilidæ, are nocturnal, except, perhaps, when newly hatched from the egg. On this subject Vorhies, '05, makes the following interesting observation: "The interesting fact was noticed that these newly-hatched larvæ are positively heliotropic to a marked degree when on a dry surface, but at once become negatively heliotropic when placed in a dish of water. The necessity of getting out from beneath stones where the eggs are placed in order to find water, and of getting beneath stones for protection while building a case, after reaching it, offers an explanation for this peculiarity."

In preparing to pupate, unlike the common method of the family, the cases of this species are not attached to any object, but lie on the bottom of the stream, sometimes under stones and sticks, sometimes on the surface of the gravel, but always with the head directed upstream. In one habitat of the species the bottom is of rather soft muck. In this spring the pupal cases were always buried under an inch or more of soil.

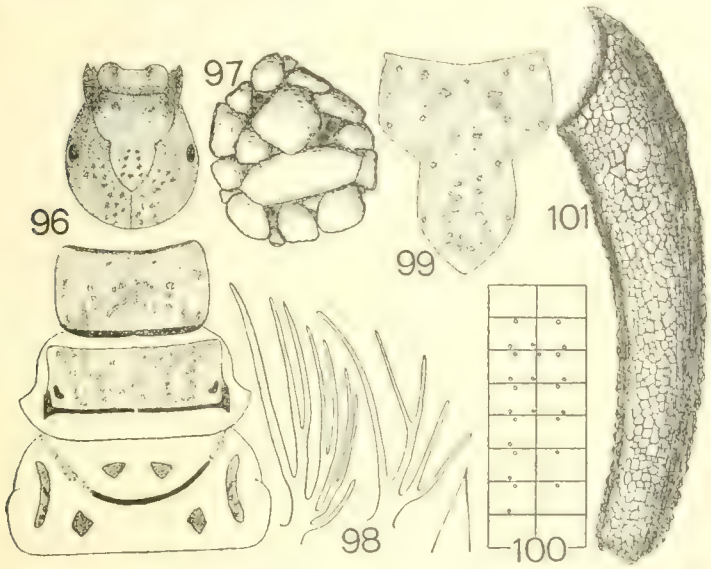
Prepupæ and pupæ can be found in every season of the year, unless, possibly, the early months of winter. Their greatest abundance, however, comes during late winter and very early spring.

Food of Larvæ.—To determine the food of the larvæ, about six stomachs of mature larvæ, and as many of young larvæ, were examined. The stomachs of the young larvæ contained only diatoms, mixed with a large amount of sand—the sand amounting to many times the bulk of the diatoms. The stomachs of the old larvæ contained about the same mixture of sand and diatoms, and also a few fragments of higher plants. Vorhies, '05, found the food of the old larvæ consisting of water-cress and water-milfoil, and in 1909 states that the young larvæ feed upon diatoms. In the springs of the McLean region there is a very sparse growth

of higher plants, which probably forces the larvæ to feed upon diatoms throughout their lives.

Period of Emerging.—The species is on the wing in greatest numbers about the middle or latter part of April, but late comers have been found in our locality until the latter part of August, and Vorhies, in Wisconsin, found several egg masses on October 12th, and one egg mass as late as November 2d. Our first specimens were taken on bright days during the very first part of April, when snow in nearby drifts was still piled to a depth of several feet. At such times the adults are not uncommon.

In leaving the cases the pupæ sometimes follow the usual method of breaking through the end of the case. More often, however, they tear out a section of the side wall, leaving a long, jagged hole in the side of the case.



PLATYPHYLAX DESIGNATUS.

96. Larva. Head and thorax.
97. End of pupal case.
98. Larva. Gills.
99. Larva. Frons.
100. Larva. Distribution of gills.
101. Case.

Description of the Larva.—Length, 18 mm.; breadth, 4 mm. In life the body is light-green in color. In form it is distinctly curved, and apparently incapable of straightening.

The Head.—Deep mahogany-brown; in some specimens so dark that the pattern is visible only in the best illumination, figure 96. The pattern is very slightly darker than the ground color of the head. On the frons, figure 99, the muscle-attachment spots are the only marking, but the ground color gradually becomes darker toward the mouth-parts. The head, in front of the eyes, is without markings; behind the eyes, on the dorsal, ventral and lateral surfaces, there is a mottling of small spots, slightly darker than the ground color. Each eye is bordered on its lower side by a crecentric mark of light color.

The Thorax.—The pronotum is of lighter color than the head; its pattern is shown in figure 96; on the under-surface there is a median dark mark near the caudal margin; the horn is dark-brown. On the mesothorax the dorsal chitinous plate has the same ground color as the pronotum. It is bordered along the hind margin by a narrow line of deep black, which widens at the angle with the lateral margin and extends about half way up the sides; on each side of the chitinous plate, opposite the end of the black marginal stripe, there is a small, deep, black mark, which sometimes blends into the black marginal line; on each side of the median ventral line, near the caudal margin of the segment, there is a curved line of about five small round chitinous spots. On the dorsal surface of the metathorax the median chitinous plates are separated by about the breadth of one of the plates; the lateral plates are somewhat crecentric in form, with a sparse growth of setæ on the cephalic third; behind these setæ the plates are marked with black.

The Abdomen.—The dorsal hump on the first segment is well developed and pointed—the lateral humps are rounded; on the ventral surface there is a broad, raised area covered with an evenly-distributed growth of black setæ. Each gill arises from a single stem and branches biramously on a single plane, figure 98. The distribution of gills is diagrammed in figure 100.

Description of the Case.—The typical case of the larva, figure 101, is made in the form of a slightly-curved cylinder, tapering gradually toward the caudal end. On the outside of the curve of the cylinder, at the cephalic end, there is a tapering hood which extends over the head of the larva, completely covering all but the legs. These cases are made of grains of coarse sand of nearly uniform size, and are lined with a tough, but brittle, sheet of silk.

In the habitat where the bottom is of muck the larvæ use small chips of bark in the structure of their cases, making them as nearly the typical form as the nature of the material at hand will allow.

The case of the pupa is like the case of the larva, except that there are pebbles of large size grouped around and over the front end of the case, giving it a rounded form. The opening at the caudal end of the case is covered and rounded with pebbles of about the same size as those of the larva's case. At each end the case is perforated through the silk lining between the pebbles, by from one to six round holes, figure 97.

The pupæ cases from the mucky situation had many small molluscs fastened to the cephalic end.

Halesus Guttifer.

Habits.—Larvæ are common in Michigan Streams below the swamp, and have been taken in Spencer Lake. It is probably a common species in many of our ponds and slow-moving streams.

In habits the larva does not seem to differ from *Pycnopsyche scabripennis,* but it has not been so well studied.

Before pupation the larvæ attach the cephalic end of the case to the under-side of a submerged log, or within some crevice of wood or bark.

Food of Larva.—Fine raspings of decomposed wood seem to be the only food of the larvæ.

Period of Emerging.—Specimens in captivity emerged during August and September. Wild specimens have been taken on the wing as late as November.

Description of Larva.—No constant characters have been found that will distinguish between the larvæ of *Pycnopsyche scabripennis* and *Halesus guttifer,* except the size and form of the spacing humps. In *H. guttifer* the dorsal and lateral humps are well developed; the dorsal hump is cone-like, terminating in an acute nipple-like process.

The description of other parts of the larvæ of *Pycnopsyche scabripennis* will apply equally well to *Halesus guttifer.*

Description of the Case.—*Halesus guttifer* makes ballast-stick cases and irregular prepupal cases, which are not distinguish-

able from those of *Pycnopsyche scabripennis,* figures 92, 94. The species has not been observed during the early season to ascertain whether it makes the flat-leaf type of case.

Platycentropus Maculipennis.

Habitat.—The larvæ live in spring-fed streams, where the water is clear and cold, and where the growth of vegetation is sparse or wanting. In limited numbers they are found in parts of Bool's Brook, but in the streams of the McLean Basin, especially in Argus Brook and the upper regions of Sphærium Stream, they are among the most common caddis-worms.

Habits.—The larvæ are bottom dwellers in streams with gentle current, and without dense growth of vascular plants. In such streams they are evenly distributed, apparently never congregating in certain areas, as do the larvæ of many other species.

Before time for pupation the larvæ attach their cases to submerged sticks or roots, or hide in the crevices of bark or wood.

Food of Larva.—No studies have been made of the food of the larvæ.

Period of Emerging.—Adults appear during the middle of July.

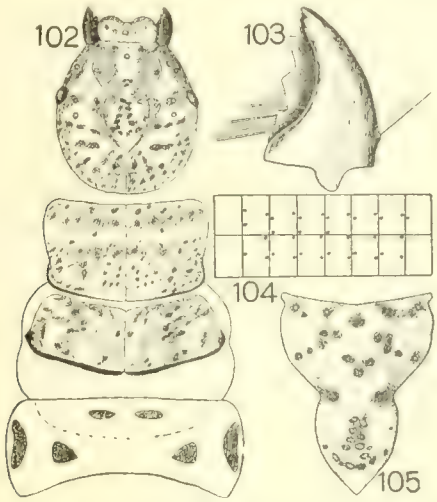
Description of Larva.—Length, 22 mm.; breadth, 4.5 mm.

Head.—The ground color is straw-yellow, shaded and spotted with brown, as in figure 102; on the under-surface there is an area of nearly round spots on the posterior part of each gena, in front of the spotted area each gena bears a single elliptical coalesced pair of muscle-attachment spots. Each mandible, figure 103, bears a line of yellow hairs on the upper margin of the inner side. The labrum has the straw-yellow ground color of the head, but is margined with brown and has a brown spot near its center.

Thorax.—The prothorax, figure 102, is light-colored, profusely spotted with brown. On the mesothorax the chitinous shield is smoky-brown, with numerous dark spots, except an area near each outer margin where the smoky appearance is absent; the black caudal margin of the shield widens at the corners into a broader mark, which has a constriction in the middle. The mesothorax, on its dorsal surface, is creased by a well-marked furrow, which

passes around the median plates; the median plates are narrow and are separated by not more than the length of a single plate.

Abdomen.—The spacing humps are flattened; the dorsal hump is surrounded by numerous scattered setæ, which are not grouped in clusters; on the ventral surface of the segment there is a lip-like elevation of the cuticle, which bears a pair of large setæ rising from dark-colored punctures; in front of the folds the setæ are scattered over the ventral surface of the segment with no tendency to form clusters; the distribution of gills is diagrammatically shown in figure 104; each gill has, typically, three branches, except on the last two or three gill-bearing segments, where the number of branches is reduced to one or two and the gills themselves are weaker.



PLATYCENTROPUS MACULIPENNIS.

102. Larva. Head and thorax.
103. Larva. Mandible.
104. Larva. Distribution of gills.
105. Larva. Frons.

DESCRIPTION OF THE CASE.—Length, 20—25 mm.; breadth, 7—10 mm. The larvæ make cases of the typical cross-stick type, selecting twigs or grasses of smaller diameter than is usual in the genus Limnophilus, and cutting off the loose ends close to the case, thus forming a case of more cylindrical and compact appearance than is usual in this type of case.

At the caudal end of the case the walls are drawn abruptly over, leaving a small circular opening to the tube.

Chilostigma Difficilis.

Habitat.—The larvæ of the species have been found in a very limited area of Argus Stream, in the McLean swamp. The stream is a small one, hardly more than a foot in width and three or four inches in depth. It rises in a sphagnum bog and penetrates a dense thicket of alder for about a half mile, when it enters a larger stream. Through the alder thicket the waters are in deep shade, and leaves and sticks litter the bottom. In this portion of the stream, so far as we can see, there are no differences of conditions within its waters. Yet this species, for the three years we have known it, has inhabited an area of the stream not more than a hundred yards in length. In this limited area it occurs in great numbers.

Habits.—Until the middle of summer is past these larvæ rest or crawl slowly about over the bottom of the stream. As the period for pupation approaches they congregate in great numbers on submerged sticks or roots. Often they occupy every available lodging space on a certain stick, while other similar sticks of the neighborhood are left entirely free from their presence. Only the front ends of the cases are attached to the support, from which they project at all angles.

Food of the Larvæ.—Stomachs examined contained quantities of fragments of wood and leaves, nothing else.

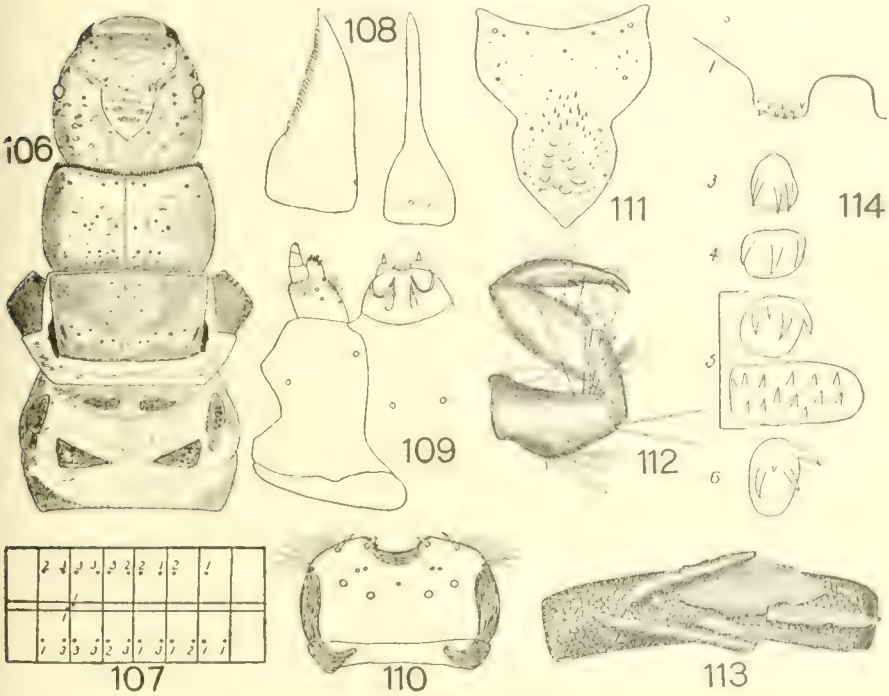
Period of Emerging.—Specimens in captivity emerged during the first half of October, but it is probable that under natural conditions they emerge throughout a longer period.

Description of the Larva.—Length, 16 mm.; breadth, 2.5—3 mm.

Head.—The color is light-brown, figure 106, almost uniform, except the dark muscle-attachment circles and a thick stippling of microscopic spots; the dorsal surface, especially the frons, figure 111, bears numerous pointed, spear-like processes, which are plainly evident in balsam mounts. The labrum, figure 110, is brown, with a darker mark behind the middle of its front margin; the innermost setæ on its front margin are short and blade-like; the outer setæ of the front margin are longer, but blade-like; other setæ of the labrum are indicated by circles in the accompanying

drawing. The mandibles are black, with a line of dense yellow hair on the top edge of the groove.

Thorax.—The prothorax is light-brown with a slightly oblique black mark on each side above the coxa; the top surface has, in



CHILOSTIGMA DIFFICILIS.

106. Larva. Head and thorax.
107. Larva. Distribution of gills.
108. Pupa. Mandible.
109. Larva. Lower mouthparts.
110. Larva. Labrum.
111. Larva. Frons.
112. Larva. Front leg.
113. Case.
114. Pupa. Chitinous plates of left side of abdomen.

addition to numerous setæ of the ordinary type, many shorter, spear-shaped, forward-pointing spines, not shown in the accompanying figure; these are most numerous along the front margin, where they project over the base of the head; the dorsal markings of the meso- and meta-thorax are shown in figure 106. The legs are light-brown, margined and marked with black. Figure 112 shows a front leg.

The Abdomen.—The lateral fringe is short and weakly devel-

oped; it extends from the front margin of the third segment to the hind margin of the eighth segment. The distribution of gills is diagrammatically shown in figure 107.

DESCRIPTION OF THE PUPA.—Length, 10—11 mm.; breadth, 2—2.5 mm. The antennæ extend back almost to the tip of the abdomen. Each side of the upper surface of the labrum bears a group of about five long, black, hooked setæ. The mandible is shown in figure 198. The lateral fringe begins near the hind margin of segment five and curves under the hind margin of segment eight; it is black in color and is much better developed than that of the larva.. The last segment bears a pair of fleshy appendages. The chitinous plates of one side of first and third-seventh abdominal segments are shown in figure 114.

DESCRIPTION OF THE CASE.—The case of the larva, when mature, is 15—20 mm. long; its diameter is 4 mm. or more at the cephalic end, according to the kind of material used in its construction. In form it is cylindrical and slightly curved. The larvæ, during their active period before pupation, construct their cases largely of quartz sand, but usually have a greater or lesser number of bark chunks around this inner cylinder. Sometimes, however, these bark fragments are almost, or even entirely, lacking. In preparation for pupation the larvæ usually remove almost all of the plant fragments from their cases. They then congregate in numbers on some support, as a submerged stick or root. Before pupation takes place the two openings of the case are stopped with small grains of sand firmly cemented in place. Apparently there is no mesh left open. Figure 113 represents a typical larval case of quartz sand and a few fragments of bark.

GENUS NEOPHYLAX.

Head.—The head is very long and narrow, held pointing backward with the under-side against the under-side of the thorax when at rest.

Thorax.—The prothorax is narrow and lacks the "horn." On the mesothorax the chitinous plates above the coxæ extend back until they meet the dorsal plates.

Abdomen.—A transverse elliptical ring marks the under-side of segments three, four, and five.

The genus offers many unsolved problems, such as the function of the gill-like structures on the first abdominal segment in certain species, and the morphological changes that take place during the long prepupal period.

The Case.—In length the case, figure 120, is about 13 mm. It has the form of a cylinder, made of fine sand grains, tightly cemented with tough, brittle silk. The cylinder is slightly curved toward the ventral side. Along the sides of the case there are several flat ballast stones.

In the prepupal or pupal state, the condition in which the cases are almost always found, the ballast stones are larger than those used during the active period, and each end of the cylinder is capped with a large pebble, figure 119.

Larvæ of at least two undescribed species were collected.

Neophylax Concinnus.

Habitat.—The species, in the immature stages, is common in the riffles of most upland streams of the region, such as Sphærium Stream, Michigan Stream, and many others. It does not seem to occur in spring basins; nor is it common in the warm water of the lowlands, though a few specimens have been found in Cascadilla Creek and in Coy's Glen.

Larval Habits.—During the winter and early spring the larvæ crawl over the stream's bottom, feeding and storing up fat to carry them over the long prepupal period, lasting through the entire summer. As spring advances they seek the support of some solid object, such as a submerged rock or log. Here the cases are firmly attached, often great numbers of them on a single rock, with the bodies parallel, like cords of wood.

In late spring, when the larvæ have attained full size and have attached their cases to some solid object, the sieve nets are spun across the ends of the cases, and the prepupal state begins.

In sealing the case the larva does not cover the ends with a silken mesh, as do other species of the family, even when flat stones also are used. Neophylax selects a stone for each end of the case that is slightly larger than the diameter of the tube. These stones are tightly cemented over the ends of the case with thick sheets of cement-like silk. On the ventral surface of the cephalic

end the sand of the tube is cut away in semi-circular form and the opening thus formed is covered with a lattice-like arrangement of heavy rods of silk, figure 119. This end of the case is held above its support by a short stalk of silk. At the caudal end of the case a semi-circular opening is not made, but the lattice-like silk rods are made between the end rock and the ventral surface of the tube. Usually the rods are overlapped by the edges of the case and are invisible from the outside.

During the long prepupal period, lasting several months, from late spring until the latter part of August, the larvæ remain quiet with their heads folded between their legs. During this period they are incapable of taking any food, and dissection shows the alimentary canal entirely void of material of any kind.

If, during this period of helplessness, the stream recedes enough to dry the cases, the larvæ perish, unable to reach the water, which may be but a fraction of an inch below.

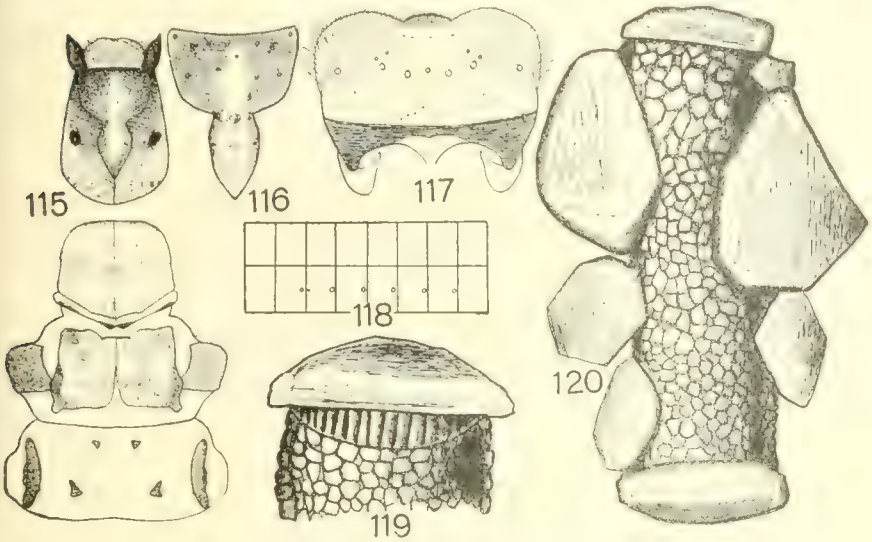
Period of Emerging.—Adults emerge about the end of the first week of October, and continue on the wing until the middle of November. They are weak flyers and do not wander far from the stream's edge.

Description of Larva.—Length (in natural position, with head turned under thorax), 8—10 mm.

Head.—In form, the head, figure 115, is long and tapering from the eyes to the mouth parts, and quite abruptly rounded behind the eyes. The frons, figure 116, seen in profile, has a decided mound-like prominence at the point between the two eyes. In color, the dorsal surface of the head bordering the frons is dark-brown, almost black on the cephalic portion, but becoming lighter as it progresses back; the frons is dark-brown, except an irregular mark of light color, figure 116; behind the dark mark bordering the frons the head is irregularly spotted with light-brown; the sides of the head are light-brown, except a narrow area surrounding each eye, which is almost white; on the under side of the head there is a broad mark of brown, which gradually shades into the light color of the sides, except along the cephalic margins, where it is narrowly connected with the dark color of the dorsal surface.

Thorax.—The prothorax above, figure 115, is light straw color,

with a dusky border along the cephalic margin and dark mottling on the caudal half; on the under side there is a chitinous plate of dark-brown color in front of the caudal margin of the segment.



NEOPHYLAX CONCINNUS.

115. Larva. Head and thorax.
116. Larva. Frons.
117. Larva. Labrum.
118. Larva. Distribution of gills.
119. Respiratory openings of pupal case.
120. Pupal case.

On the mesothorax the chitinous plates above the articulation of the coxæ extend up to the lateral margins of the dorsal shield, with which they are narrowly united; on the under side of the segment there is a pair of chitinous plates in front of the caudal margin; the dorsal plates, figure 115, have a varying pattern of dark-brown on a lighter field.

Abdomen.—On the first segment the dorsal hump is represented by an elongate chitinous plate; the lateral humps are prominent and of darker color than the surrounding cuticle; on the dorsal surface there is a line of sparse setæ passing in front of the dorsal hump and ending well above the middle of the lateral humps; on the ventral surface there is an elevation which bears a pair of small chitinous spots, each with a single seta; midway between this elevation and each lateral hump there is a thumb-like structure of doubtful function. On the ventral surface of seg-

ments three, four, and five, there is a transverse elliptical ring of chitin. The gills, figure 118, are weak and of varying number.

Description of the Case.—The case of the mature larva is about ten millimeters in length. It is constructed of small or minute sand grains, firmly cemented together in the form of a slightly flattened and slightly curved tube. On each end of the tube the larva cements one or more heavy "ballast" stones, figure 120.

Neophylax Automnus.

Larval Habits.—The larvæ are found in spring basins and in spring streams near their sources. In the McLean region they are especially abundant in Big Spring and its outlet for a few hundred feet. They do not seem to occur in streams far from their sources, nor have they been found where there is any great inflow of surface water. These spring streams, in which the larvæ occur, are swift-flowing, with stony bottoms, and practically void of vascular plants and of sticks and surface litter.

Larval Habits.—In habits the larvæ do not seem to differ from *N. difficilis*.

The prepupal behavior, also, is apparently like that of *N. difficilis*.

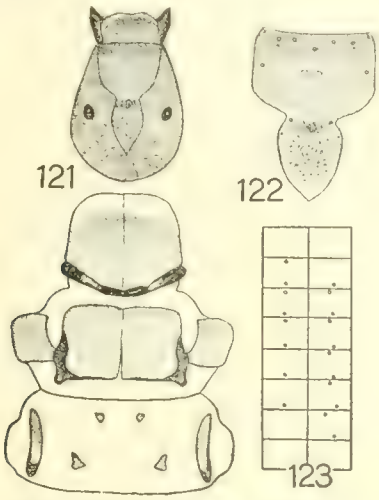
Period of Emerging.—Adults are on the wing from late September until early November.

Description of Larva.—Length (in natural position, with head turned under thorax), 7 mm.

Head.—In form the head, figure 121, is similar to that of *N. difficilis*, except that it is narrower across the cephalic margin. In color it is deep mahogany-brown, almost black, except a light-colored semi-circular area around the under surface of each eye, and some small light-colored spots behind and beneath the eyes. On the frons, figure 122, there is a thorn-like projection that is plainly visible in profile view.

Thorax.—The cephalic third of the prothoracic shield, on the dorsal surface, is creamy white; behind this light area it is dark smoky-gray. The mesothoracic shield is smoky-gray with indistinct markings, and bordered on the lateral and caudal margins with black, as in figure 121.

DESCRIPTION OF THE CASE.—The case differs from that on *N. concinnus* only in its slightly smaller size, and in the smaller number of the "ballast rocks" used during the prepual condition. The manner of sealing the case before pupation does not seem to differ from that of the previous species.



NEOPHYLAX AUTOMNUS.

121. Larva. Head and thorax.
122. Larva. Frons.
123. Larva. Distribution of gills.

FAMILY SERICOSTOMATIDÆ.

The family, as it now stands, consists of four widely-separated subfamilies. No group characters have been found that will satisfactorily include the larvæ of these subfamilies and exclude members of other families.

The same evidence of distant relationship prevails in the habits as in the classification. For this reason no attempt is here made to discuss the family as a whole, but the known local species will be described and discussed under their separate headings.

HELICOPSYCHE BOREALIS.

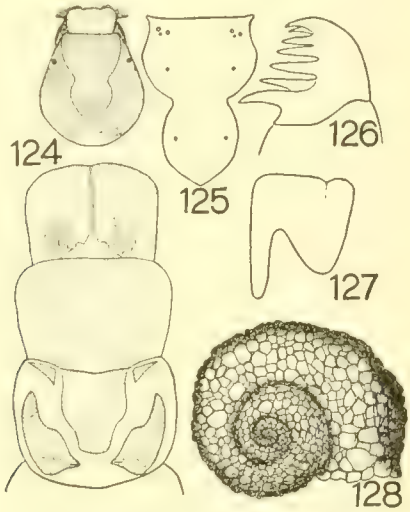
HABITAT.—The larvæ are found in almost all stony streams of the region, and also occur on the rocks of exposed shores of Cayuga Lake. Vorhies, who studied the Trichoptera of both streams and lakes in Wisconsin, found the larvæ only in the lakes.

In view of this discrepancy in habitat, and also in the difference of size of both adults and larvæ, it seems probable that there are more than one species in the genus. Dr. Betten, however, after careful study of a large number of adults, could find no characters for distinction, except size, and recognizes but one American species in the genus.

Habits.—In many of the streams about Ithaca the larvæ are very abundant, but are difficult to discover during larval life, while they live among the sand and gravel of the stream's bottom. Shortly before pupation they attach their cases firmly to some submerged rock or log, usually selecting a rough surface. At this time they often display a gregarious instinct, large numbers congregating within a very small area. It is during the prepupal and pupal periods that they are most often collected.

Period of Emerging.—Adults emerge from the latter part of June until the end of July.

Description of Larva.—Length, 6 mm. The larva, when removed from case, assumes a spiral position of at least one and a fourth turns.



HELICOPSYCHE BOREALIS.

124. Larva. Head and thorax.
125. Larva. Frons.
126. Larva. Drag-hook.
127. Larva. Chitinous support, middle leg.
128. Case.

Head.—The dorsal surface of the head, figure 124, is dark-brown, except along the margins of the frons, where there is a very narrow light line which broadens at the constriction of the sclerite; there is also a light-colored area in front of the caudal margin of the head, and a light circular area surrounding each eye. The caudal third of each side of the head has numerous light-colored muscle-attachment marks. On the ventral surface the head is white, with several conspicuous dark-brown muscle-attachment marks on each side of the gula.

The Thorax.—The pronotum, figure 124, is brown, with a varying pattern of light and dark marking; on each side of the segment the chitinous support for the leg has a deep notch, figure 127, into which a tongue-like extension of the coxa hinges.

Abdomen.—On the first segment the dorsal hump is absent, and the lateral humps are but slightly raised and are thickly covered with minute spines, arranged in pairs. Gills and the lateral fringe are absent. The drag-hooks bear several long teeth, figure 126, giving each hook a fan-like shape.

The abdomen is curved to fit the form of the case, as the insect lives with its ventral side toward the axis of the whorl.

Description of the Case.—The well-known spiral case, figure 128, quite closely resembles some of the fresh water molluscs, for which it has been more than once mistaken and described. It is made of minute sand grains, securely cemented together. The tube in which the larva lives is broadest at the mouth and tapers gradually to the tip.

Though the mollusc-like case of the genus Helicopsyche is a unique plan of architecture, it is not such a wide deviation from the cases of other Trichoptera as appears on first sight. Apparently the larva starts its case in somewhat the form of a minute horseshoe and, continuing the cephalic end around the caudal end, builds on until the spiral form is reached, ever-increasing the diameter as it builds around the circumference.

Such a case would be made by a species that makes a cornucopia-shaped dwelling, such as *Leptocerus ancylus,* figure 167, if the bend in its case were very greatly increased and the tube slightly elongated.

Before pupation the case is tightly glued to some solid support and the cephalic end is closed by a convex lid of silk, with a

split-like respiratory opening on the side toward the axis of the whorl. Behind the caudal end of the pupa a flat sheet of silk with several respiratory openings crosses the interior of the case.

Goera Calcarata.

Habitat.—The larvæ are found in riffles of the large streams of the region, both in the uplands and near the lake's level. They also occur on stones in wave-beaten areas on Cayuga Lake's shore.

Habits.—Little has been learned of the habits of the larvæ, beyond the fact that they are found crawling over the surfaces of bare, current-swept rocks from late summer until the end of March, when they attach their cases firmly on the exposed edges of stones, together with *Psilotreta* and a few other species of the rapid waters.

Period of Emerging.—Adults emerge during the last week of April and the first week of May.

Description of Larva.—Length, 10—12 mm. There is a heavy chitinous spur above each mesothoracic leg, grooved on its cephalic margin to fit a groove on the lateral margin of the pronotum.

Head.—The back part of the head, figure 129, on the dorsal surface, is flattened and slopes toward the caudal margin; in front of this flattened area, whose boundary passes in front of the eyes, the head is cone-shaped, sloping toward the mouth-parts. In color the entire head is uniform black-brown, except a slightly lighter circular patch surrounding each eye.

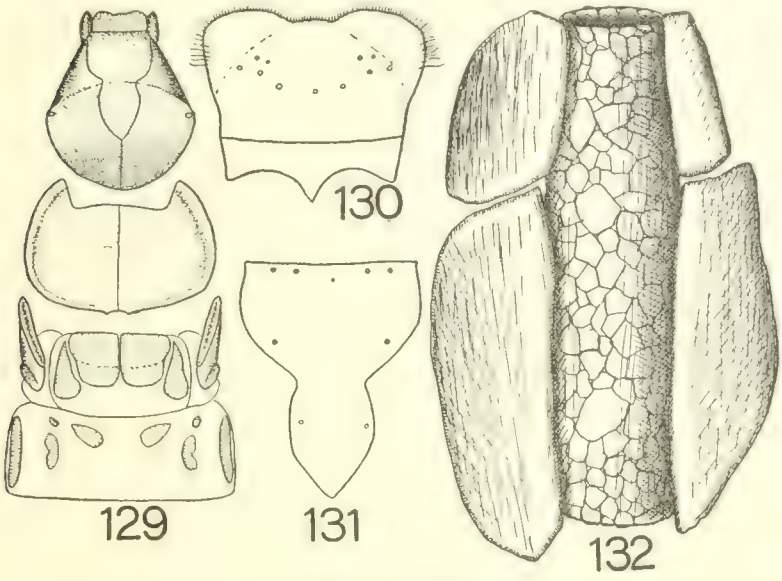
The Thorax.—The pronotum, figure 129, is very heavily chitinized. The cephalic margin is inset so that the lateral margins extend forward in sharp points. The lateral edges are thick and deeply grooved, apparently to fit the grooves of the heavy chitinous spurs of the mesothorax.

On the mesonotum there are two pairs of large chitinous plates, figure 129. Above each mesothoracic leg there is a very heavy chitinous spur, grooved on its cephalic margin, which projects well beyond the cephalic margin of the segment.

The metathorax bears four pairs of chitinous plates, figure 129.

It is to be observed that in the European fauna the genus Gœra has two pairs of plates on the mesonotum and only three pairs on the metanotum, while the genus Silo has four pairs of

plates on the metanotum, but has three pairs on the mesonotum. Thus *G. calcarata* seems to fall in neither of these genera. The adult, however, seems to agree best with the genus *Gœra*.



GOERA CALCARATA.

129. Larva. Head and thorax.
130. Larva. Labrum.
131. Larva. Frons.
132. Case.

The Abdomen.—On the first segment the dorsal hump is well developed; the lateral humps are present, but flattened. Branched gills and the lateral fringe are present. The drag-hooks are stout and bear but a single spur.

Description of the Case.—The case, figure 132, has the form of a tube of fine sand grains. The tube is very slightly bent and is slightly flattened on the ventral side. Fastened to each side of the tube are heavy ballast stones—usually two to each side.

Before pupation the larva places a stone over the opening at each end of the tube. Across the face of each stone a solid sheet of silk is spun. In the crevices between the stone and the tube a series of elongate respiratory openings are left. The case is fastened to its support by a stalk of silk at each end.

The preparation for pupation, like the form of the case, is very similar to those of Neophylax.

Brachycentrus Nigrisoma.

Habits.—During the first six weeks of their lives the larvæ are active, crawling about in quiet eddies along the banks of the stream in search of food. After this period they move to the center of the stream and live sedentary lives, with one edge of the large end of their cases firmly cemented to submerged rocks or sticks. Always they inhabit positions on the exposed surface of their support and always they face the unbroken current. While waiting for prey they assume the position shown in figures 142 and 144, protruding their heads slightly and extending their prothoracic legs straight forward. The mesothoracic legs are held upward while the metathoracic legs are extended to the sides. From this position they eagerly seize and quickly devour small larvæ or bits of vegetation that float within their grasp.

In the unnatural conditions of still-water aquaria in the laboratory they attach their cases and assume their characteristic attitude of outstretched arms. If a particle of food material be moved within their grasp it is eagerly seized and devoured, but if, however, the food be placed in front of the larva, even in contact with its limbs or jaws, it is ignored or pushed aside. Apparently the larva does not recognize food that is not moved into its grasp. From time to time larvæ confined in aquaria detached their cases and moved from place to place. It seems probable that the larvæ in the streams, also, at times move about in search of building material, for it is unlikely that chance would place enough suitable case-building material within their reach.

Larvæ which were put in the water after they had been exposed to the air until the moisture had dried from their cases, which accordingly floated, swam with their legs motionless and in the attitude assumed while waiting for prey. Their motion through the water was caused by the respiratory current being forced through the small openings at the caudal ends of their cases, somewhat after the manner of locomotion of certain dragonfly nymphs. This was probably an unnatural mode of locomotion, never practiced in nature, at least not by this species.

In preparation for pupation the larva spins a silken sheet, figure 148 C, across the front of the case. This sheet is perforated in the center by a number of small holes arranged in a circle. Surrounding the perforations there is an area which is free from

perforations. At the caudal end of the pupa (about two-thirds the length of the case from its cephalic end) a second sheet of silk, figure 148 B, crosses the case. This second sheet resembles the first, except that the circular area of perforations is larger. Pupation takes place on the exposed areas on sticks or stones where the larval life was spent.

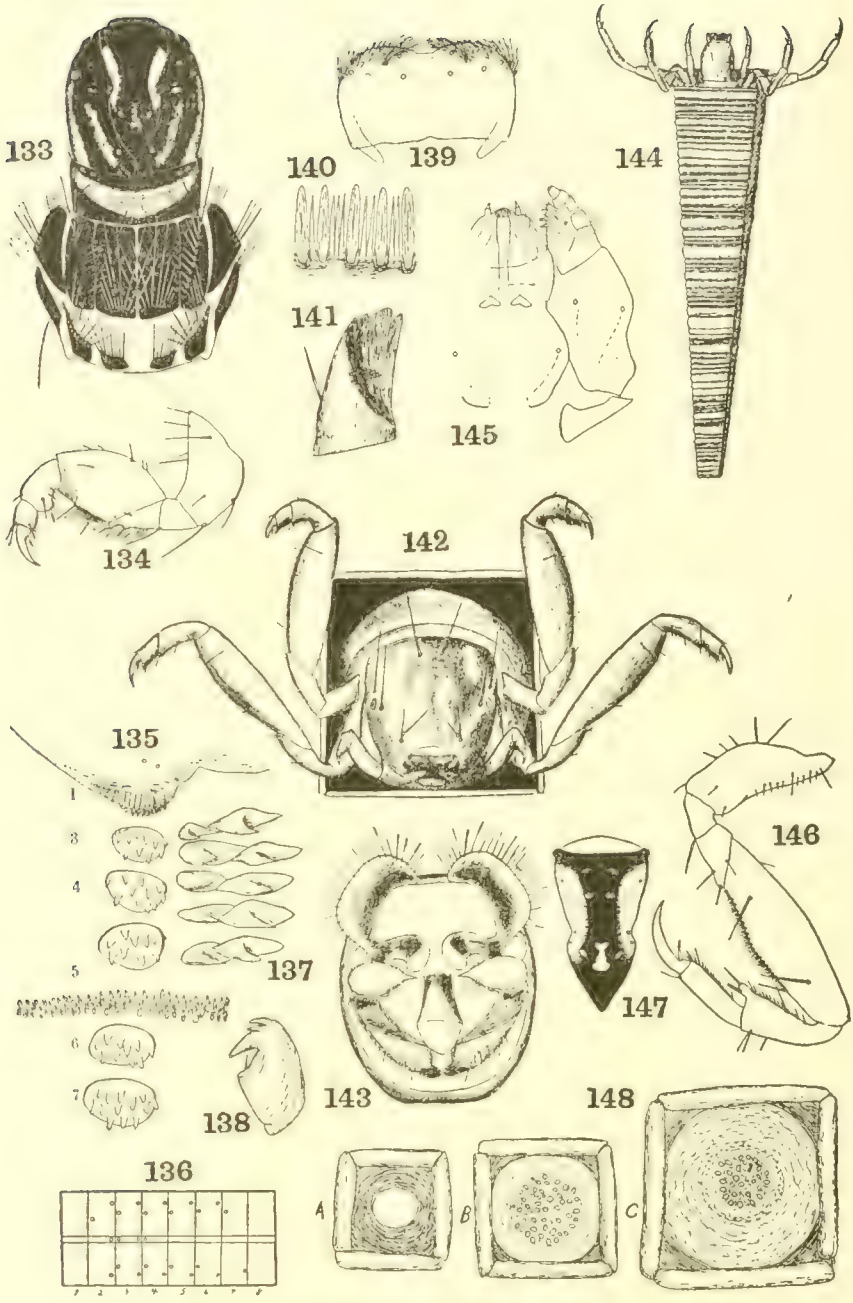
Period of Emerging.—Specimens confined in cages in their natural habitat emerged during the latter part of May and first part of June.

Food of the Larvæ.—According to Miss Helen Murphy, who followed the species from the egg to the adult, "the cases are completed in about five hours. The larvæ then start to eat. For the first two weeks the food consists entirely of diatoms, such as Meridion, Cymbella, Navicula, Cocconema, Fragilaria, and Synedra. This food they obtain by browsing on the stones and vegetation, over which they hastily scramble. At the end of the third week the green algæ Oedogonium, Cladophora, Ulothrix, Cylindrospermum, and bits of seed plants are added to the diet."

"At the end of the sixth week the larva is about three-sixteenths of an inch in length." "From a purely herbivorous diet, obtained by active searching, they now become mainly carnivorous, waiting in a most receptive attitude for whatever may come within their powerful grasp." "An examination of their stomachs at this time reveals quantities of fragments of mayflies, Hydrachnids, Chironomids, and Crustacea, as well as Chlorophyceæ and diatoms of several genera. This miscellaneous assortment of animal and vegetable foods from the stomachs, as well as observations on the habits of the larvæ, leads us to believe that they will eat any organic matter that floats within their grasp. The combs of fine spines on the legs (figures 134, 140, and 146) seem to serve as plancton sieves, and the long, hooked armature of the tarsus certainly is adapted to a carnivorous diet."

Description of the Larva.—The length of the mature larva, figure 133, is about 12 mm.; its breadth is about 2.5 mm. In life the soft parts are green; the heavily chitinized parts are dark-brown, appearing black when viewed in reflected light. The abdomen tapers gradually from the first to the last segment.

The Head.—The head is black, marked with brown on the



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dorsum, figure 133; the sides are black, with a brown mark extending back from the caudal margin of the eye to the caudal margin of the head as shown in the figure; the venter is black, except the ventral mouth-parts, which are brown; the labrum is black, with setæ arranged as in figure 139; its cephalic pair of setæ are saber-like and are directed toward the median line, their tips almost meeting; the other setæ are normal; the front margin is clothed with a dense fringe of hairs; the frons has the markings and distribution of setæ, shown in figure 147.

The Thorax.—The thorax is marked on the dorsum, as in figure 133; the prothorax has a depressed crescentic mark of brown across the dorsum and extending down the sides; the mesothorax is armed dorsally with four narrowly separated chitinous plates, which are without markings, but are armed with long setæ, figure 133; on each side of the body there is a somewhat triangular plate; the metathorax is armed above with four smaller dorsal plates and a single plate on each side of the body, figure 133; on the sides the chitin of the dorsum of the prothorax extends to the base of the front legs; on the outside of each mesothoracic coxa there is a triangular piece of heavy chitin which bears a tuft of long, black setæ on its front and on its ventral corners; the metathorax bears similar chitinous pieces, each of which has a single line of long, black setæ around its cephalic corner and a line of similar setæ, extending from a point on its cephalic margin well above its ventral corner to a point on its venter considerably below the limits of the chitinous triangle; the venter of the thoracic segments is without heavy chitin. The legs, figures 134 and 146, are

BRACHYCENTRUS NIGRISOMA.

133. Larva. Head and thorax.
134. Larva. Front leg.
135. Pupa. Chitinous plates of left side of abdomen.
136. Larva. Distribution of giills.
137. Pupa. Detail of group of hooks, 2nd series, segment 5.
138. Larva. Drag-hook.
139. Larva. Labrum.
140. Larva. Part of comb of 2nd leg.
141. Larva. Mandible.
142. Larva in case. Natural position, cephalic view.
143. Adult. Male genitalia, caudal view.
144. Larva in case. Dorsal view.
145. Larva. Lower mouthparts.
146. Larva. Middle leg.
147. Larva. Frons.
148. Pupal case. a) caudal end of case. b) caudal sieve. c) cephalic sieve.

all armed with powerful curved claws; the form and distribution of setæ is shown in the accompanying figures; the apical membranous part of the front femur adjoining the tibia is somewhat soft and is overspread with minute conic teeth; the inner edge of the trochanter and femur of the front leg is armed with a single row of long straw-colored hairs, and the femur is armed also with a row of short spines on its inner edge; the second and third pairs of legs are much alike; the inner edge of the femur is armed with a line of sharply-pointed spines of two kinds—one kind, apparently very rigid, is dark in color and arises from well-defined sockets; these spines are separated by one, two, or three spines of lighter color and apparently less rigidity, which do not arise from sockets; the spines in detail are shown in figure 140.

Figure 136 illustrates diagrammatically the arrangement of gills on the left side of the abdomen.

Description of the Pupa.—Length, 10—13 mm.; breadth, 3—3.5 mm.

The mandibles are strongly chitinized. The antennæ reach to the tip of the abdomen. The dorsal plates of the abdomen and armature of the dorsal surface of the first segment are shown in figure 135; the hooks of the second series on the fifth segment are not borne on a single plate, but occur as independent chitinous pieces, forming a line across the dorsum of the segment. Figure 137 shows the hooks in detail. A few minute setæ occur on each segment—these are slightly longer and more numerous on the last segment; the lower sides of segments 1 to 7 bear narrow obliquely downward-pointing lines of dark color; the last segment is shaped like an obtuse arrowhead. When viewed from above its two curved processes are equal to a little more than half its length. The lateral fringe is better developed than that of the larva; it begins behind the middle of the fifth segment and ends on the ventral side of segment eight.

The Case, figure 144, is 15—18 mm. wide at its anterior end and about 1.5 mm. wide at its posterior end; it is constructed of minute twigs, root fibers, and fragments of wood cut to the proper length to give even and straight edges, gradually diverging toward the anterior end. In cross-section the outer surface of the case is square; the interior is lined with a cylindrical tube of tough silk, which is equal in diameter to the inside diameter of the square

exterior framework; the spaces between the corners of the square exterior and the silken tube are filled with silk. At the caudal end of the case, figure 148 A, the tube narrows abruptly, leaving a circular opening about one-half mm. in diameter. So toughly made are these cases that they persist without deterioration from season to season after their occupants have left them.

FAMILY CALAMOCERATIDÆ.

This small family is represented in North America by but eight described species. Other members of the family, except two species in Europe, occur in remote countries where little or nothing has been done with the immature stages.

For this reason it is impossible to assemble a group of family characters with any degree of certainty that they will include all of the species of the family when these become known.

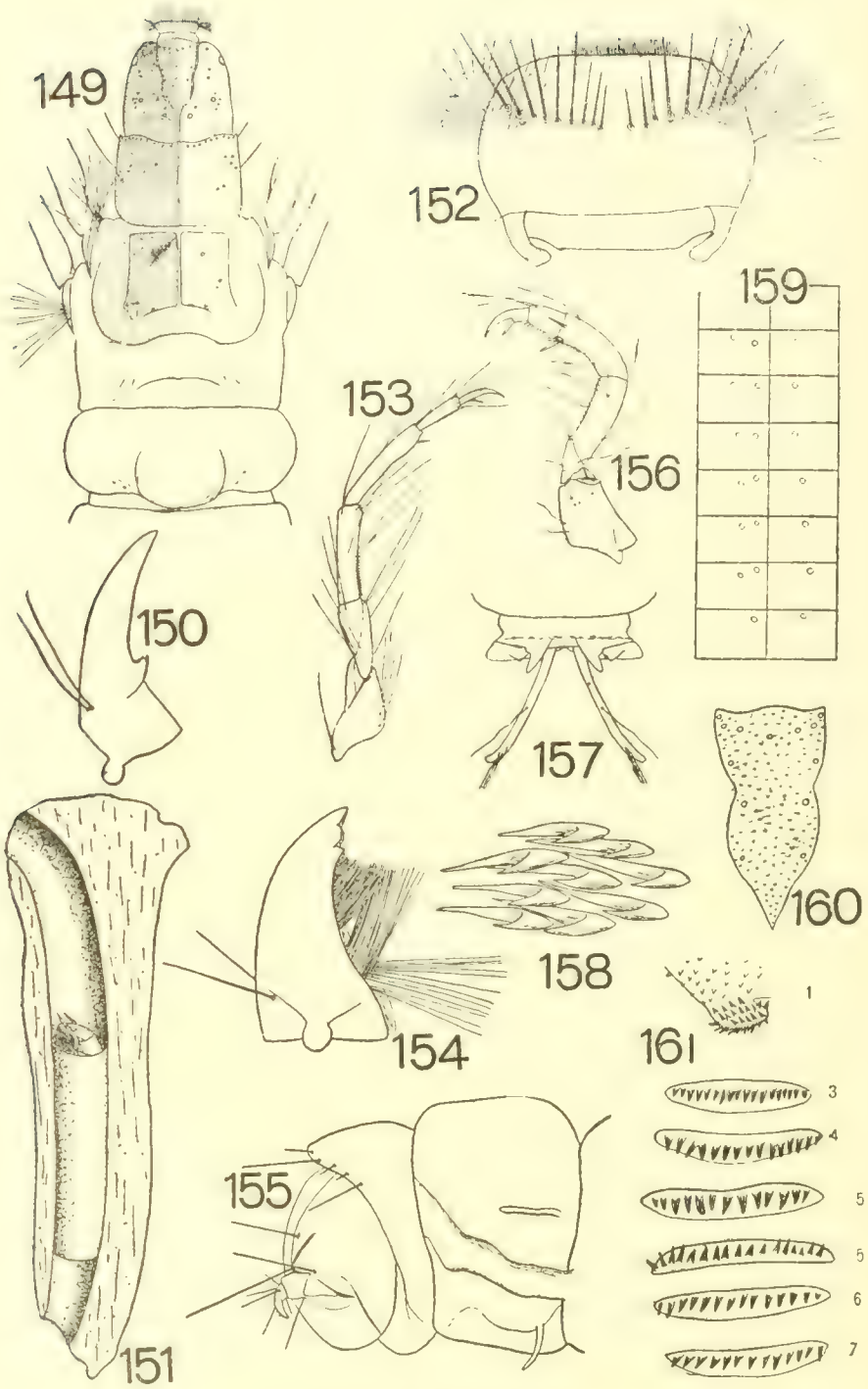
Ganonema americanum, the only known American larva, is described below.

Ganonema Americanum.

Habitat.—The larvæ are abundant in the alder-bordered streams of Michigan Hollow and McLean Swamp.

Habits.—The larvæ are active during the summer, fall, and winter. In February, with the thermometer below 20° Fahr., they were apparently as active as during the heat of summer. By the end of April they had left the middle of the stream and had firmly attached the anterior ends of their cases to solid supports near the stream's margin. At this time flat stones were fastened over both ends of their cases—a frequent practice of the larvæ at all seasons during periods of rest.

The wood-boring habits of this species may, when we are familiar with more species, prove a not uncommon method of case-making. I have found identical cases in streams on the Western slope of the central range of the Colombian Andes, and also in the Valley of the Magdalena River, east of this range. Similar habits are described and figured by G. V. Hudson, in "New Zealand Neuroptera," 1904, for *Triplectides obsoleta (Pseudonema obsoleta)* of the family Leptoceridæ. Hudson, however, states that *T. obsoleta* under natural conditions sometimes constructs cases of fragments of leaves.



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Food.—The food of the larvæ, as demonstrated by examinations of the contents of many stomachs at different seasons, consists of fine powder rasped from submerged wood.

Period of Emerging.—The specimens in captivity emerged from June 4 to July 11.

Description of the Larva.—Length, 18—20 mm.; width, 3 mm. Color of chitinous portions of head and thorax, black when viewed with reflected light; when viewed with transmitted light, mounted specimens show faintly lighter markings. The legs are black, ringed with white. Fleshy portions of prothorax and abdomen are pale-brownish white. The anal hooks are brown.

The Head.—The head is narrowest at its anterior end and broadens very gradually to near its base, where it narrows. Behind the place of its greatest diameter it is inclosed within the first thoracic segment. The distribution of setæ on the dorsal surface is shown in figure 149. The frons, figure 160, has a semi-circular line of setæ, curving away from the cephalic margin and three other more widely-separated setæ near each side. Like the heavily chitinized portions of the head and thorax, the frons is thickly marked by minute transverse lines, from each of which arise several very minute hairs, giving, except under high power, a somewhat scale-like appearance. The mandibles, figure 154, are deeply grooved along their inner margin to the very tip of the apical tooth. Besides the apical tooth, two lateral teeth are present on each edge of the groove. From the groove arise three well-defined brushes of hair. The inner brush is directed inward and backward; the middle and cephalic brushes are directed inward and toward the front; the cephalic brush is the most dense and is composed of extremely fine hairs. The labrum, figure 152, is crossed by a row

GANONEMA AMERICANUS.

149. Larva. Head and thorax.
150. Pupa. Mandible.
151. Case, longitudinal section.
152. Larva. Labrum.
153. Larva. Hind leg.
154. Larva. Mandible.
155. Larva. Terminal abdominal segments. Lateral view.
156. Larva. Front leg.
157. Pupa. Anal appendages, dorsal view.
158. Larva. Detail of hooklets covering lateral humps.
159. Larva. Distribution of gills.
160. Larva. Frons.
161. Pupa. Chitinous plates of left side of abdomen.

of 18 to 20 strong setæ whose bases almost touch, except on the median line, where there is a greater space. On each latero-anterior angle there is a patch of long, fine hairs, and in the middle of the cephalic margin a dense line of short hairs.

The Thorax.—Prothorax heavily chitinized above and on the sides. The area between and in back of the coxal cavities is membranous, except two narrow spots immediately in front of the mesothorax. Mesothorax with a chitinous area which extends back over the metathorax as far as the caudal margin of the hind coxæ. Within this area there is a well-defined, square bearing eight setæ, figure 149. The sides are not chitinous, except for a small black triangle behind each coxa, which bears a circle of about twelve setæ; the venter is free from heavy chitin, except for two narrow yellow spots on the caudal margin. The metathorax is without heavy chitin above. On the sides the distribution of chitinous plates is the same as on the mesothorax; the upper mark, however, is not so dark in color as on the preceding segment and bears more setæ, which are less nearly circular in arrangement. The venter differs from that of the mesothorax, only in having the chitinous areas near the caudal margins darker in color. The front leg, figure 156, is little more than half the length of the succeeding legs, but is more robust. It bears three stout spurs on the inner angle, next to the tarsus, and one isolated spur on the distal margin. On the inner margin of the basal segment of the tarsus there is a single row of short stout spines. The inner surface of the tibia bears numerous very short spines. The inner surface of the femur is sparsely armed with short triangular teeth. The coxa, on its inner margin, has a few short spines and over its entire surface has rows of fine, short hairs like those described for the frons. The two succeeding legs (figure 153 shows the hind leg), differ from the front leg in being longer and less robust, and in having fewer and weaker short spines. Each of these legs has but one tibial spur.

The abdomen is cylindrical and almost uniform in circumference throughout its length. The humps on the first segment are not greatly developed. The lateral humps bear an area of short, curved spines, whose points are directed forward. The gills are distributed on segments 2 to 8, above and below the lateral line, as diagrammed in figure 159. The lateral fringe, near the caudal

margin of the seventh abdominal segment, ends at the beginning of a fleshy raised line, figure 155, which crosses the suture between the seventh and eighth segments and, inclining upward, extends to the caudal margin of the eighth segment. Each side of this fleshy line is armed with curved, bifurcate spines directed backward. The anal hooks and the arrangement of setæ on the last abdominal segments are shown in figure 155.

Description of the Pupa.—Length, 13 mm.; mandible, figure 150. Tarsi flattened and fringed on each side by a row of black swimming hairs. Lateral fringe black. A narrow black line parallels the lateral fringe beneath, extending to the caudal margin of the eighth segment, where the two converge. A narrow black line above the lateral line contains the spiracles. Abdominal segments 2 to 9 have tufts of hair near their caudal margins above. On the caudal margin of the first abdominal segment there is a pair of lobes, figure 161, covered with sharp spines. Above these lobes are sparse backward-pointing teeth. The chitinous plates of the abdomen are shown in figure 161. The posterior end of the pupa is represented in figure 157.

The Case.—The cases made by this species differ greatly from those of other described American Trichopterous larvæ. Instead of the usual dwellings of stones or twigs, or tubes of silk, these utilize fallen twigs of wood from the stream-bottom. The twigs are hollowed from end to end, and lined with silk, forming portable cases, which are a natural part of their surroundings. These larvæ abound among the litter of branches and twigs from the surrounding forest. In spite of their abundance they are most inconspicuous among the débris. They crawl with a jerky motion, as if swayed by the passing current, or rest, as if lodged, on a submerged branch, and when disturbed, let go, drifting down stream with the current.

The twigs used in cases vary greatly in length and diameter, apparently being selected at random from the litter on the bottom of the forest stream. Sometimes pieces of heavy bark or fragments of broken wood are used. A cylindrical hole always penetrates the wood from end to end. In some twigs the chamber forks near the anterior end, one outlet curving downward and opening to the exterior at one side, while the other perforates the end of the stick. The side outlet, when present, forms the anterior

entrance to the case, the other in the end being plugged with silt or with small pebbles. Sometimes the chamber curves downward without forking, as in figure 151. The chamber is always lined with silk. (Figure 151 represents a case with the silk tube cut away, except around the larva.) Although there is considerable variation in the size of the twigs used, their average size increases with the growth of the larvæ. To ascertain how the change in cases is made, several experiments were made with captive larvæ. Some were removed from their cases and put in cages with twigs of appropriate size. These larvæ did not attempt to use the wood for making new cases, but merely spun silken tubes to which particles of silt adhered; others, which had one side removed from their cases, repaired the damage with silk and silt. One larva repaired the damaged side with silk and fragments of bark and then proceeded to cut away the two ends of its case. It worked from the damaged side of the case, cutting narrow incisions across the twig until the opposite side was reached. The operation of cutting the two incisions across the twig ten millimeters in diameter consumed about twenty-four hours. Two specimens, which were retained in aquaria in the laboratory, attached the anterior ends of their cases securely, by means of silk, to the ends of solid twigs, and then drilled into the wood, emitting, during the task, an abundance of very finely-powdered wood. One of these new dwellings proved too long for its occupant. It was accordingly girdled with a circular incision, which was deepened until one end of the twig was completely cut away. Several sticks similarly ringed were found in the creek where the larvæ occur. No doubt this is the usual method of changing cases, as larval growth proceeds.

FAMILY ODONTOCERIDÆ.

This small family is represented in the American fauna by but a single species with known immature stage.

Distinctive Characters.—The labrum is distinctly longer than broad. The pronotum and mesonotum are chitinized; the metanotum has four chitinous plates, the two median of which are much broader than long, crossing the median line.

The Head.—The head is depressed in form. The labrum is longer than broad, with two pairs of cycle-shaped, pale setæ on

the front margin. The pleuræ are contiguous behind the small, triangular gula.

The Thorax.—The pronotum is extended in a thorn-like point at each cephalic corner.

The mesonotum is completely chitinized.

The metathorax bears two broad chitinous plates transversely across the dorsal surface, and a single plate on each side.

Psilotreta Frontalis.

Habitat.—Psilotreta larvæ inhabit almost all of the larger streams of the uplands, but are never found near Cayuga Lake's level. They are especially abundant in Mud Creek, near Freeville.

In the upland streams the larvæ are confined to the riffles, and the portions of the streams with stony bottoms.

Habits.—During their early life the larvæ are free moving, crawling over the stream's bottom. At this time they show no evidence of social instinct, coming together only by chance in their wanderings.

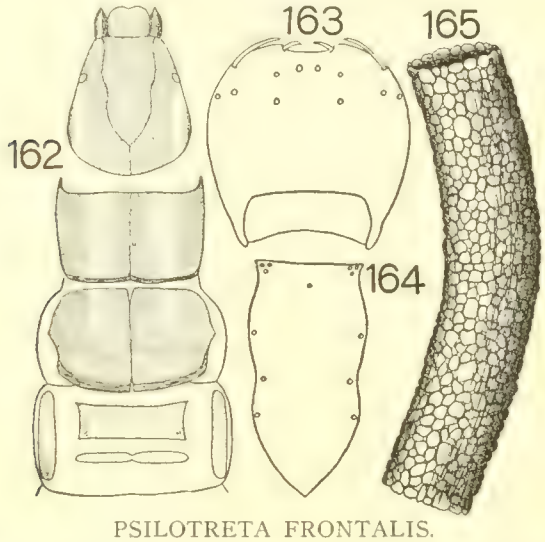
In the early spring, just before pupation, the larvæ develop a remarkable gregarious habit. Almost all of the larvæ within certain areas of the stream congregate on the sides of a few selected stones in such numbers that their cases are sometimes piled one on top of another to a depth of an inch or more, while other stones of the region are entirely uninhabited. The cases are always placed parallel to each other, with their cephalic ends directed toward the surface of the water. Such congregations of cases may often be removed entire from the supporting stone, when the mass has much the form of a cord of neatly cut wood.

Period of Emerging.—Adults emerge during the latter week of May and the first week of June.

Description of Larva.—Color in life deep blue-green.

Head.—On the dorsal surface the head is flattened. In color it is deep mahogany-brown, with a light line commencing at each eye and extending back to the caudal margin, and a narrow light cephalic border to the labrum, figure 162. On the ventral surface the head has a light-brown median mark, which shades into deep mahogany-brown toward the lateral margins.

The Thorax.—The chitinous shield of the pronotum is extended forward in thorn-like form at each cephalic corner. In color the pronotum is deep mahogany-brown, with a broad, lighter-brown line on each side of the median suture.



PSILOTRETA FRONTALIS.

162. Larva. Head and thorax.
163. Larva. Labrum.
164. Larva. Frons.
165. Case.

The shield of the mesonotum is deep mahogany-brown, with a lighter line on each side of the median suture, which, in some specimens, ends at about the middle of the sclerite, and in other specimens extends back to the caudal margin of the shield.

The metanotum, figure 162, bears a broad, brown, transverse plate near the cephalic margin, behind which there is a pale, narrow, transverse plate; on each side of the segment there is an elongate brown plate.

The Abdomen.—On the first segment all three spacing-humps are represented by obtuse mounds. The gills of the subdorsal and subventral series are well developed, occurring in tufts of from five to twenty-five filaments behind the cephalic margin of the segment. The lateral series of gills is represented by a few weak filaments on the first three or four gill-bearing segments, or is entirely wanting. The drag-hooks are stout, with heavily chitinized supports on the prolegs.

DESCRIPTION OF THE CASE.—The case of the mature larva, figure 165, has the form of a slightly-curved cylinder of sand grains. Immature larvæ cases differ only in being tapered toward the caudal end.

The case of the pupa has a flat pebble set neatly within the aperture at each end of the tube. All spaces around these stones are tightly closed with heavy silk, leaving no respiratory apertures. The habit of enclosing the pupa tightly, without provision for respiratory currents, is unusual among case-building Trichopterous larvæ, but is always practiced by the cocoon-making family, Rhyacophilidæ.

FAMILY LEPTOCERIDÆ.

HABITAT.—The known Leptocerid larvæ of the American fauna are inhabitants of standing waters—lakes, ponds, and the dilatations of streams—except *Leptocerus ancylus,* which is found on stones in the riffles of streams, as well as on the stones of wave-beaten lake shores.

Though the most abundant of our Trichoptera belong to this family, the early stages of but few have been described, and the habits of these few are but imperfectly known. At times, during the early days of July, the black iron bridge across the northern end of Cayuga Lake appears as white as snow, with millions of adult insects of this family, mostly the beautiful snowy species of the genus Leptocella. At such times a passing train sends a cloud of countless numbers of the insects into the air, after a few minutes' flight to settle again as a white covering upon the bridge.

HABITS.—The habits of so few species of our fauna are known that it does not seem advisable to generalize on the activities of the entire family. Those that are known will be described under the various species.

DESCRIPTION OF THE LARVÆ.—*Distinctive characters.* A suture beginning in the region of the eye dips downward and extends back to the hind margin of the head. The femur of the hind legs, and in most species of the middle legs, is divided into two segments.

The Head.—The head is oval, with long antennæ arising close behind the mandibles. The labrum is much broader than long,

and never possesses a row of twenty or more heavy bristles. The gula is subquadrate, widely separating the epicrania.

The Thorax.—The pronotum is chitinous. On each side of the prothorax a chitinous plate, differing somewhat in form in different species, extends forward above the base of each coxa.

The mesonotum is chitinized.

The metanotum lacks chitinous plates.

The legs will offer unusual taxonomic opportunities when they are more thoroughly studied and the homology of the segments is better known.

The forelegs are short, broad, and flat, with varying armature in different species.

The middle and hind legs are slender and show great difference in armature, and in the relative length of the segments. In the hind legs of all known species, and in the middle legs of all except Setodes, there is a short segment at the base of the femur, which has led Ulmer to state that the femur is divided. It is not clear, however, that this segment does not belong to the trochanter instead of to the femur. Besides this suture, cutting off a sclerite of doubtful homology, there is, as is usual in Trichopterous larvæ, a suture near the base of the trochanter. In the Leptoceridæ this suture separates a short basal piece from a much longer distal piece.

The Abdomen.—On the first segment all three spacing-humps are well developed. The lateral fringe is short and fine and extends from the third to the seventh segment. The basal segments of the prolegs are fused to form an apparent tenth segment. The claws are small.

In this family it is impossible to identify the species by fragments of the cast larval skin retained in the case after pupation. The exuvia is eliminated through the caudal opening of the pupal case as soon as transformation from the larva takes place.

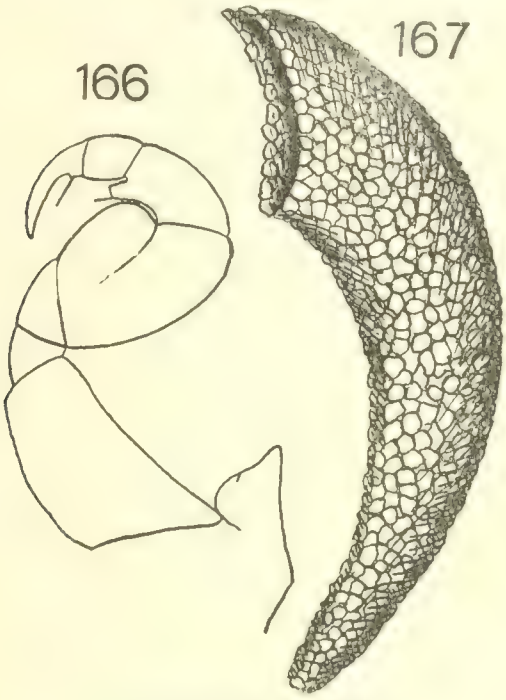
Leptocerus Ancylus.

The larvæ are common in all streams of the region, except those of the highest altitudes; and they also occur on stones of the wave-beaten shores of Cayuga Lake.

Vorhies, who first described the larvæ and adults, determined

the Ithaca specimens as identical with his material from Wisconsin, in spite of the decided difference in form of the larvæ's cases.

The color and soft parts of our specimens deteriorated in the preservative fluid, but the structure of the chitinous parts is well preserved. The fore leg of the larva is shown in figure 166.



LEPTOCERUS ANCYLUS.

166. Larva. Front leg. 167. Case.

In the Ithaca region the larvæ make cases of sand grains in the form of curved cornucopias, figure 167, without lateral flanges, and without decided hood-like covers on the cephalic ends. In cross-section the cases are cylindrical.

The cases of the material from Wisconsin have decided lateral flanges, and have well-developed hoods that completely cover the larvæ's heads.

Mystacides Sepulchralis.

Habitat.—The larvæ are common insects in Beebe Lake, Dwyer's Pond, and in many of the slow, deep pools of Cascadilla and Fall Creeks.

Habits.—The species lives among the accumulation of sticks and rubbish on the pool's bottom.

The prepupal state has its beginning from the middle of May till the first part of June. At this time the cases are attached to the exposed surfaces of submerged sticks.

Food.—Stomachs of preserved specimens contained a thoroughly masticated pulp, apparently of vegetable origin.

Period of Emerging.—Specimens in captivity emerged from the middle of June until the first part of July. Probably under natural conditions their period of emerging is of considerably longer duration.

Distinctive Characters of Larva.—Length, 9 mm. Without swimming hairs on second and third pairs of legs.

Head.—The extent of the dark coloring varies greatly in different individuals. In dark specimens, figure 168, the cephalic part of the frons is smoky-brown; behind the brown area the head is pale yellow, except for several sharply-defined spots behind the frons; a dark mark begins behind each antenna and extends back to the hind margin of the head; the sides of the head are pale yellow with numerous dark-brown spots; on the under surface the head is dark-brown without markings.

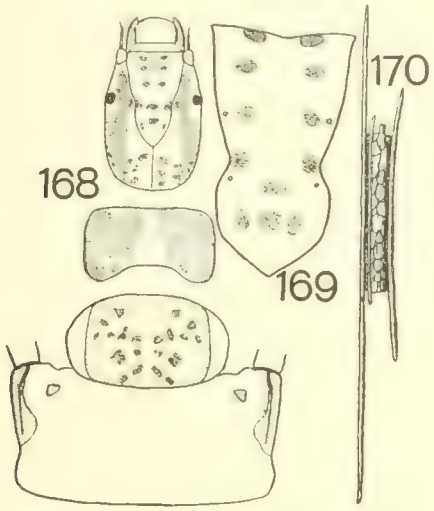
Pale specimens have a ground color of light straw yellow, marked by numerous brown spots. No other markings are present.

The Thorax.—The prothorax, like the head, is subject to great variation in coloration. Dark specimens, figure 168, have the ground color of the prothorax almost entirely dark-brown, almost obliterating the mottling; in such specimens a narrow, light-colored line encircles each "shoulder." In light-colored specimens the ground color is pale, thickly mottled with dark-brown spots. All intermediate gradations of coloration occur.

The mesothorax of dark specimens is smoky, mottled with dark-brown, figure 168. In light specimens the smoky ground color is lacking.

The metathorax has a small chitinous plate bearing a few setæ on each "shoulder."

The fore leg is broad and flat. The middle leg bears a tarsal claw that is as long as the basal tarsal joint. The distal segment



MYSTACIDES SEPULCHRALIS.

168. Larva. Head and thorax. 170. Case.
169. Larva. Frons.

of the trochanter is more than twice as long as the basal segment. The femur is divided into a long apical and very short basal piece. The hind leg bears a tarsal claw about half as long as the basal joint. The tibia has a swelling at about the middle of the segment that gives the segment the appearance of being divided, though carefully-prepared mounts have revealed no suture. The femur is divided into a short basal and long apical piece. The basal piece of the trochanter is short and the apical piece very long.

The Abdomen.—The first abdominal segment has a prominent bulb-shaped dorsal spacing-hump; the lateral humps are smaller; on the caudal side of each lateral hump there is a brown chitinous plate with a black dorsal margin. Abdominal gills are absent. The lateral fringe consists of weak, pale hairs. The drag-hooks are stout; chitinous supports at their bases are almost entirely wanting.

Description of Case.—The case of the larva, figure 170, consists of a slightly-tapering tube of sand grains, or minute bark

fragments, lined with silk. In length the tube is about 12 mm., and in breadth about 1.5 mm. On opposite sides are fastened pine needles, or grass stems, or slender sticks, paralleling the tube and extending well beyond its caudal and cephalic ends.

Before pupation a sheet of silk with a slender, minute, round perforation in the center is spun across each end.

Triænodes Sp.

Habitat.—The larvæ are common in the Cove, Michigan Pond, and many ponds and dilatations of creeks that contain Potamogetons and other aquatic plants.

Habits.—The larvæ dwell among the branches of submerged plants, seldom descending to the pond's bottom. Unlike other species that dwell in similar places, but must crawl from plant to plant, the larvæ of Triænodes swim rapidly from place to place through the open water.

Before pupation the cases are attached to the stems of plants or rolled in submerged leaves.

Period of Emerging.—Adults emerge about the middle of June.

Distinctive Characters of Larva.—Length, 10 mm. Long swimming hairs on third pair of legs.

Head.—The ground color is straw yellow, figure 171; a dark mark on each side of the frons begins at the outer corner of the labrum and extends back to the hind margin of the head, with a narrow break behind the antenna; on the ventral surface a smoky area begins at the base of each mandible and extends back to the hind margin of the head. The gula is pale. The frons, figure 172, is without pattern. The mandibles are brown.

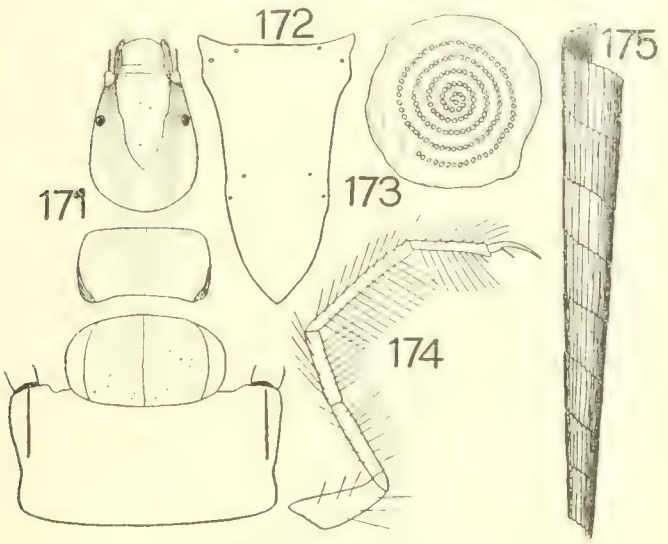
Thorax.—The prothorax is smoky on the dorsal surface, shading to straw yellow on the sides. The chitinous supports at the base of the legs are dark-brown and black. A thorn-like process projects forward above the base of each coxa.

On the mesothorax the scutellum is of a pale, smoky color, with indistinct dark spots. The pleural suture is long and narrow, and deep black in color.

The metathorax bears no dorsal chitinous plates. The pleural

suture is very long, extending diagonally up and back three-fourths the distance to the caudal margin of the segment.

The front leg is short and stout. The tibia is broadened on its inner distal angle and bears a single spur. Projecting forward, above the base of the leg, there is a flat chitinous projection which differs but slightly from that of Setodes, figure 178.



TRIAENODES SP.

171. Larva. Head and thorax.
172. Larva. Frons.
173. Egg mass.
174. Larva. Middle leg.
175. Case.

The middle leg is longer and less stout. The femur is divided into a long apical and very short basal piece. The trochanter has the apical piece more than twice as long as the basal piece.

The hind leg is long and slender, and is provided with numerous long swimming hairs. The distal piece of the trochanter is much longer than the basal piece, appearing as a distinct joint.

The Abdomen.—On the first segment the spacing humps are large and bulb-like; the lateral humps have no chitinous plates, but have a thick fringe of microscopic forward-pointing hairs. The lateral fringe is present, but is very weak. Large gills arising singly occur on segments 2 to 8, inclusive. Except for the drag-hooks the prolegs are not chitinized.

Description of Eggs.—During the latter half of June egg masses may be found on the under surface of floating leaves and sticks. The gelatinous mass is disc-shaped, measuring about 5 mm. in diameter. Inside the gelatin the eggs are arranged in a spiral of about 200 eggs, figure 173.

The egg masses occur in very great numbers, often completely covering the under sides of submerged leaves, or even placed one on top of another.

Description of Case.—In form the case is an elongate cornucopia, usually measuring 1.5 cm.—2.5 cm. It is made of thread-like sections of the epidermis of leaves, or the fine ribs of leaves, wound in a spiral. The leaf sections are cut and fitted end to end and side to side with wonderful skill and precision.

By the time newly-hatched larvæ have left the gelatinous egg mass, they have constructed irregular, web-like cases of transparent silk. To this silk case silt adheres. After two or three days from the time of hatching the silk case is replaced by the characteristic spiral case of the species.

Setodes Grandis.

Habitat.—In the beds of *Potamogeton americanus* in Spencer Lake the species occurs in great abundance. At an earlier date Professor Comstock found the larvæ abundantly among the aquatic vegetation at the north end of Cayuga Lake. During recent years, however, it has been impossible to find a single specimen in this situation.

Habits.—In Spencer Lake the larvæ feed on *Potamogeton americanus*. On this plant they, with their brilliant green color showing through their transparent cases, can hardly be distinguished from the stipules of the leaves of their food plant, which they resemble exactly in size and form.

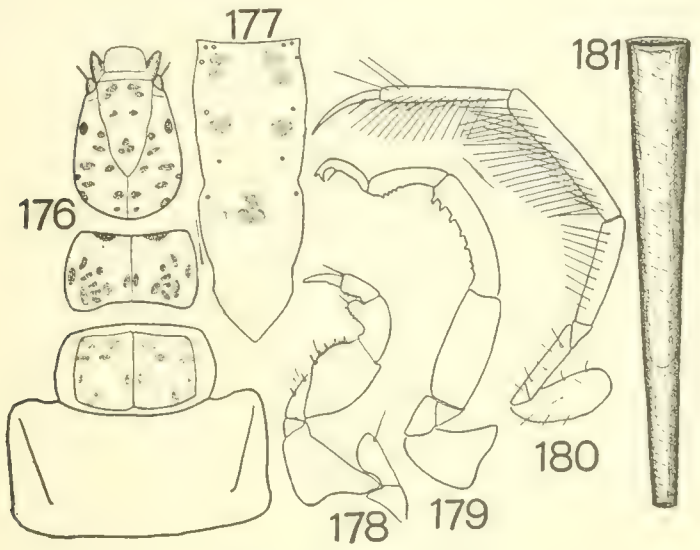
Vorhies experienced great difficulty in distinguishing the larvæ from the spine-like leaves of *Ceratophyllum*, on which he found them common in Wisconsin.

Before pupation one side of the cephalic end of the case is made fast to the host plant, leaving the case projecting in a decidedly spine-like manner. The pupa, like the larva, is brilliant green and shows its color distinctly through the transparent case.

The peculiar curved form of the tibia and basal tarsal joint of the middle leg indicates some peculiar habit in the larval life of this species.

Period of Emerging.—Our earliest record of emerging is June 20th. At that time most specimens had pupated, but a few were still in the prepupal state. These late specimens would probably emerge about the middle of July.

Distinctive Characters of Larva.—Color light-green in life. Length, 9 mm. Tarsus of middle leg curved, figure 179. Swimming hairs on hind legs.



SETODES GRANDIS.

176. Larva. Head and thorax.
177. Larva. Frons.
178. Front leg.
179. Middle leg.
180. Larva. Hind leg.
181. Case.

Head.—The ground color of the head is pale straw yellow; on the dorsal surface it is spotted with dark-brown, as in figure 176; the ventral surface is without marks. The mandibles are deeply grooved, and have several teeth on the inner surface; in color they are brown.

The Thorax.—The prothorax is straw yellow, mottled with oval brown spots, as in figure 176.

On the mesothorax the dorsal plates are straw yellow, with a few dark oval spots.

The metathorax is without chitinous plates.

The legs are illustrated in figures 178, 179, and 180. On the middle leg the tarsal claw is forked near its tip; the basal joint is slightly curved and is armed with about five thorns on its inner surface. The tibia is slightly curved and is armed with several prominent thorns on its inner surface. There is no indication of a suture in its femur.

The hind leg has numerous long swimming hairs. The short basal segment of the femur is well marked. The trochanter is divided into a short basal and long apical piece.

The Abdomen.—Gills are absent on this species, though they are present on the species of the genus in the European fauna.

Description of the Case.—The case has the form of an elongate cone. It is made of pale yellow transparent silk, through which the color and form of the bright green larva or pupa can be distinctly seen. Under a lens the separate strands of silk can be plainly seen, wound in spiral form like the leaf fragments in the case of Triænodes.

The case of the pupa, figure 181, has a convex disc of silk across its cephalic end. In the center of this disc there is a small circular opening. At the caudal end of the pupa's body, about one third from the caudal end of the case, there is a strongly convex partition of silk with a comparatively large circular opening in its center. Through this opening the caudal appendages of the pupa sometimes project, and through it the cast skin of the last larval molt is eliminated.

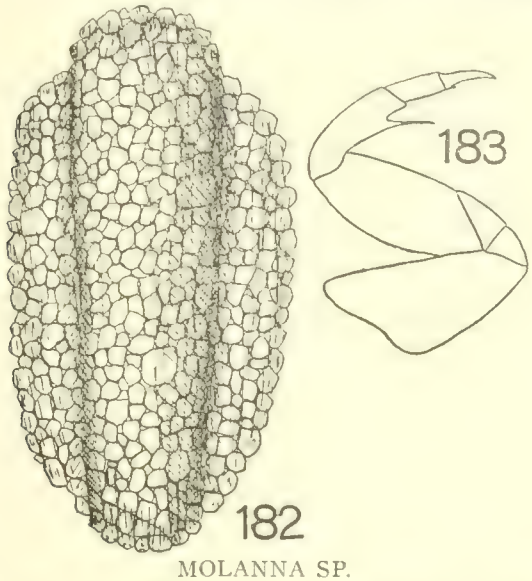
FAMILY MOLANNIDÆ.

In the American fauna only the genus Molanna has known immature stages.

Description of the Larvæ.—The gula is subquadrate, widely separating the pleuræ. The pronotum and mesonotum are chitinized, the metanotum membranous. The prosternal horn is lacking. All three spacing-humps are present on the first abdominal segment.

Genus Molanna.

Habitat.—Larvæ of the genus Molanna were found in the sand of a small stream in the McLean swamp. Unfortunately the



MOLANNA SP.

182. Case. 183. Larva. Front leg.

alcohol evaporated from the bottle of preserved specimens, leaving the larvæ worthless, but the cases did not deteriorate.

Adults of the genus are not uncommon near Cayuga Lake, from which they probably emerge.

Habits.—The larvæ observed were neatly nestled in the sand of the stream's bottom, where the wings of their cases blended so perfectly with the surrounding sand that they were most difficult to detect. Probably the genus would be found not uncommon if the cases could be more easily seen.

The Larvæ.—Molanna is the only American genus of the subfamily Molanninæ, which can readily be distinguished by the spur of the middle and front tibia. In Molanninæ the spur arises on a distinct prominence, while in the subfamily Beræinæ the prominence is entirely absent. Figure 183 represents the front leg of *Molanna uniophila,* furnished by Mr. Vorhies.

FAMILY HYDROPSYCHIDÆ.

The family is divided into two subfamilies. The Macronematinæ are abundant in the Great Lake region, but have not been found in the vicinity of Ithaca. Their larvæ probably live in large lakes and slow-moving rivers. As yet there is no published account of their immature stages.

The subfamily Hydropsychinæ is represented in our fauna by a few species belonging to three genera. These have been carefully studied by Miss Alice Noyes and have been recorded by her in 1917, and in the manuscript of a forthcoming paper. The present account of the larvæ is condensed from the work of Miss Noyes.

HABITS.—The habits of our three genera of Hydropsychinæ differ one from another only in minor details. The best-known species are recorded in the genus Hydropsyche, but probably most authors have not made generic determinations within the family. Hydropsychid larvæ dwell only in swift-flowing waters and on the wave-beaten shores of lakes. In these situations they occur in vast numbers. Miss Noyes seems to have found it not uncommon to find as many as 165 larvæ on a square of the stream's bottom measuring only 8½ x 8½ inches. The larvæ are most abundant on the exposed surfaces of stones, ledges, and even on the brinks of falls. In these situations they build the characteristic nets that are so well known in the literature on entomology. The nets, typically, have a semicircular opening facing upstream. From this opening the net extends back in bag-like form. The front end is made of fine silk, strengthened by irregular coarse strands. Behind the fine-meshed front margin there is an area of coarser mesh that acts as a seine. It is made of tough strands running in two directions, forming a mesh of minute squares, through which the water passes while straining out its burden of plancton and small insects. The larva lives in a silken tube at one end of the seine. From this retreat it can freely enter the trap to feed upon its catch of aquatic organisms.

FOOD OF THE LARVÆ.—Young larvæ feed upon green and blue-green algæ. In later life they change their diet to include also diatoms and various vegetable plancton, as well as Ostracods and

the larvæ of aquatic insects, such as mayfly nymphs and the larvæ of Chironomids.

In eating the insects the larvæ do not chew their victims, but grasp them with their fore legs and thrust them bodily into their alimentary cavity.

DESCRIPTION OF THE LARVÆ.—The head is small. On the inner margin of the left mandible there is a tuft of bristles. The labrum is entirely chitinized.

All three thoracic segments bear dorsal chitinous plates. The prosternal horn is lacking. Branched gills are present on the meso- and meta-thorax.

The abdomen bears branched external gills and retractile rectal gills. Spacing-humps and the lateral fringe are lacking. There is no chitinous shield on the dorsal surface of the ninth segment, but the ventral surfaces of the eighth and ninth segments bear chitinous plates. Each proleg is armed with a tuft of long bristles slightly above the claw.

FAMILY PSYCHOMYIDÆ.

The family includes only four genera and about thirty-five species. Of these all are confined to Europe, except a half-dozen species belonging to two genera, which occur in North America. The life histories of none of the North American species have been published.

DESCRIPTION OF THE LARVÆ.—Head, prothorax, and the last abdominal segment smaller than the rest of the body. Head compressed. Mandibles asymmetrical, the left with two teeth on the inner margin, and with a thick brush of hairs in the groove; the right mandibles lacks teeth on the inner margin, and lacks a brush in the groove. On the thorax the pronotum alone bears a chitinous plate. The prosternal horn is lacking.

The European species of the family make no portable cases, but live on stones in long, loosely-spun galleries of silk and sand grains. They are found mostly in swift water, but also inhabit ponds and lakes.

FAMILY POLYCENTROPIDÆ.

HABITAT.—The larvæ are common insects in all swift streams of the region, and in many situations of standing and slow-moving water.

HABITS.—In the swift streams about Ithaca several genera live among the rocks, making nets of different form. The habits of these have been described by Miss Noyes, 1914.

Several species of the genus Phylocentropus live in still or slowly-flowing water with sandy or muck bottoms. These larvæ spin subterranean tubes of silk, which sometimes reach ten centimeters in length. Often the tubes have one or more branches, and always they contain a bulbous swelling near the middle in which the larva probably rests, and in which pupation takes place. In natural position the tubes are beneath the ground, except about half an inch which projects upward into the water.

In summer, when the water recedes, it is not uncommon to find the exposed muck margins of upland swamp streams broken by innumerable quantities of these Phylocentropus chimneys, projecting upward into the air.

The genus offers an interesting field for future study to ascertain how the larva lives and feeds within its tube; how it uses its long, needle-like labium in spinning, and what particular use is made of its peculiar mandibles, legs, and other characteristic structures.

FOOD OF THE LARVÆ.—The larvæ of the species that have been studied feed upon plancton organisms and small insects that become entrapped in the mesh of their tubes.

DESCRIPTION OF THE LARVÆ.—The frons extends back to the caudal margin of the head, completely separating the epicrania. The labrum is entirely chitinized. The pronotum is chitinized, the meso- and meta-nota are soft.* Spacing-humps, the prosternal horn, the lateral fringe, and external gills are absent. There is no chitinous shield on the dorsal surface of the last abdominal segment. The prolegs are long, and are not fused on the median line to form an apparent tenth segment.

*In an exotic subfamily all three thoracic segments are chitinized dorsally.

FAMILY PHILOPOTAMIDÆ.

The larvæ are common in most swift streams of the region.

Among the stones of the bottom, where the force of the current is broken, they spin delicate nets of fine silk. In form the nets resemble the finger of a glove, attached at the open end, which is directed upstream, and free at the closed end. In the closed end of the net there is a small slit, just large enough to allow the escape of the larva in case of danger. The nets are 25—40 mm. in length and 3—4 mm. in breadth. They often occur in great numbers, completely covering the stones with a thin flocculent mass of dirty silk.

Though these nets cannot stand the full flow of the unbroken current, it is necessary that they be situated where there is enough flow of water to keep them distended. On lifting a net-covered stone from the water the nets invariably collapse, appearing as a mass of diatomaceous ooze through which the larvæ rapidly wriggle backward.

While the nets of the Philopotamid larvæ serve as hiding-places, their principal function is to serve as sieves through which the flowing water is strained; the larvæ feeding on the microscopic organic particles that are entangled in the mesh.

Description of Larvæ.—In color the larvæ are orange or yellow. The head is compressed; the labrum is entirely membranous; the cephalic margin of the frons is asymmetrical; the mandibles are asymmetrical, without tufts or bristles. The prothorax is the only thoracic segment that is chitinized dorsally. The abdomen has but few long hairs; the prolegs have but two long and two short bristles, slightly above the drag-hooks; gills, spacing-humps and lateral fringe are lacking.

Description of the Case.—Until nearly time for pupation the larvæ build the silken nets previously described. Before pupation they cover themselves with a rather irregular dome of pebbles, between which respiratory aperatures are left.

A careful study of the habits of the larvæ was made by Miss Alice Noyes, 1914, followed by a more detailed study with descriptions of the immature stages, the results of which are as yet in manuscript. On the results of this work the present account of the family and key to the species are based.

KEY TO LARVÆ PHILOPOTAMIDÆ.

A. Anterior margin of femur without a spur terminated by a bristle, anterior margin of clypeus but slightly indented. Lateral lobes of labrum but slightly developed.—*Philopotamus distinctus* (?)

A.A. Anterior margin of femur with spur terminated by a bristle, anterior margin of clypeus deeply indented. Lateral lobes of labrum well developed. *Chimarrha.*

B. Larva orange. Anterior margin of clypeus with deeper and more angular incision.—*C. aterrima.*

B.B. Larva pale yellow. Anterior margin of clypeus with shallower and more curved incision.—*C. socia.*

FAMILY RHYACOPHILIDÆ.

HABITAT.—Rhyacophilid larvæ are fitted for life only in flowing water. Representatives of the family may be found in all of our streams that flow over a stony bottom and that do not go entirely dry during any part of the year.

HABITS.—Members of the two subfamilies differ widely in their larval habits. Members of the subfamily Rhyacophilinæ build no cases until the prepupal stage is reached. They crawl actively under or between stones, obtaining a firm hold on their support with their well-developed drag-hooks and legs. They are active larvæ that easily crawl about without the protection of a case. When their activity is about to cease for pupation, they build a strong fence of stones about themselves and in its protection undergo pupation.

Members of the subfamily Glossosomatinæ build cases of sand grains or pebbles. With their cases they crawl slowly over the exposed surfaces of stones. They are sluggish larvæ that cannot exist without the protection of a case. Pupation takes place on the exposed surfaces of stones, within their cases of sand.

Before pupation members of both subfamilies spin a sheet of silk closely about themselves. This silken cocoon has a strong superficial resemblance to the puparia of the higher Diptera. The silk of the cocoon is rubber-like in appearance, and even under the microscope shows no texture whatever, and no openings for transpiration of water are apparent. If taken from water and

dropped into strong alcohol the cocoon collapses, giving additional evidence that it contains no openings.

Food.—The Rhyacophilinæ sometimes eat filamentous algæ, but show a preference for small larvæ. The larvæ are taken into the stomach entire, without any chewing or mutilation.

The food of the Glossosomatinæ is not known. Stomachs examined contained a structureless material that could not be identified.

Emergence.—Some species emerge throughout the entire summer, while the transformation of others is restricted to a short period.

Description of Larvæ.—The abdomen consists of nine segments; the prolegs are not fused to form an apparent tenth segment. Spacing-humps, prosternal horn, and lateral fringe are absent; external gills are absent on all known American species, but occur on some European species; rectal gills are present on some, perhaps all, species, but are usually retracted and not easily seen; the abdomen is but little wider than the thorax.

Key to the Larvæ of Rhyacophilidæ.

A. Drag-hooks plainly more than half as long as last abdominal segment. Without transportable cases.—*Rhyacophilinæ.*

A.A. Drag-hooks plainly less than half as long as last abdominal segment. Larvæ with transportable cases.—*Glossosomatinæ.*

Sub-family Rhyacophilinæ.

Description of Larvæ.—The head is long and flattened, truncate at the cephalic margin. The abdomen is depressed, with deep constrictions at the sutures; the prolegs are well developed, and extend parallel to the axis of the body; their claws are long. The maxillary lobes are long and slender.

Rhyacophilinæ.

A. Apparently two pairs of well-developed drag-hooks. Conspicuous dark-brown pattern passes transversely across middle of head.—*Rhyacophila fuscula.*

A.A. Apparently but a single pair of well-developed drag-hooks. No transverse pattern across middle of head.—*Rhyacophila torva.*

Rhyachophila Fuscula.

Larval Habitat.—The species is common throughout the region in all fast-running streams with stony bottoms. They are numerous in the permanent streams on the upland hills, but are far more common in the stony gorges near the lake's level.

Larval Habitat.—Until the prepupal state is reached the larvæ build no cases, but crawl naked beneath the stones of the stream's bottom. For life in this situation the flat body and wedge-like head of the larvæ are well adapted, and any form of portable case would be an incumbrance that would make its mode of life impossible.

Food of Larvæ.—Examinations of stomachs indicate that the larvæ live on a mixed diet of animal and vegetable food, with animal material taken in greatest abundance. Only one stomach examined contained nearly pure contents of the filamentous algæ, *Cladophora*. Two stomachs contained a little *Cladophora* mixed with *Chironomid* larvæ; and six stomachs contained nothing but *Chironomid* larvæ. In all cases where *Chironomid* larvæ were found they were swallowed whole, with no mastication whatever.

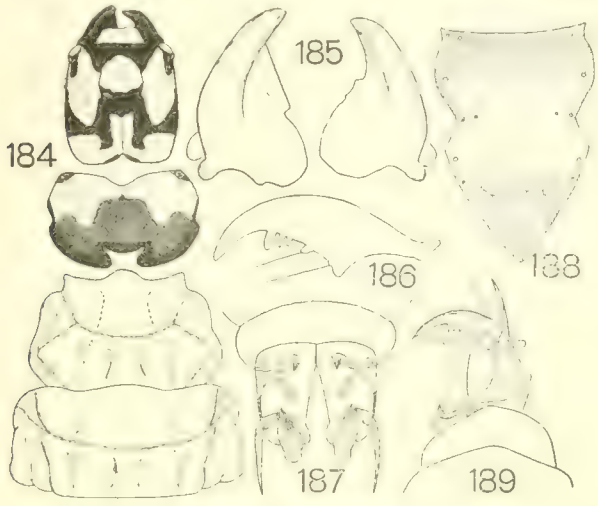
Prepupal Habits.—In preparing to pupate the larva makes the first case of its life—not a portable or close-fitting case like those made by most Trichopterous larvæ, but a roomy corral-like inclosure of pebbles. Inside of the corral the larva spins a puparium-like sheet of silk closely about itself. Within this case transformation takes place.

Period of Emerging.—Specimens were taken on the wing from the latter part of May until the middle of July. It is probable, however, that more careful collecting will discover adults emerging during the greater part of the summer.

Description of Larva.—Length, 20 mm. Color in life, dark-green, changing to brown in alcoholic specimens.

The Head.—The ground color is straw yellow, with dark-brown markings subject to slight variation, figure 184. Behind each eye there is an elongate subcutaneous mark of jet black; at the caudal margin of each side of the head there is a jet black mark. On the ventral surface the head is straw yellow, except

bordering the mouth parts, where it shades into brown. The mandibles are black and differ in form, as in figure 185. The labrum is small and is very weakly chitinized.



RHYACOPHILA FUSCULA.

184. Larva. Head and thorax.
185. Larva. Mandibles.
186. Larva. Drag-hook.
187. Larva. Prolegs, ventral view.
188. Larva. Frons.
189. Larva. Prolegs, lateral view.

The Thorax.—The chitinous dorsum of the prothorax is straw yellow, marked with dark-brown, as in figure 184. Each episternum is extenuated forward into an upturned spine-like projection which bears a seta at its tip. The ventral surface is free from chitinous plates and is without a horn.

On the meso- and meta-thorax dorsal chitinous plates are lacking. The pleural sutures are deeply sunken, giving a bulbous form to the bordering integument above the bases of the coxæ.

The Abdomen.—The abdomen is somewhat flattened and the sutures are deeply constricted, giving a decidedly corrugated appearance. External gills are entirely absent—spacing-humps and lateral fringe are lacking. The drag-hooks are well developed; each movable claw, figure 186, has three teeth and two prominent setæ on its lower surface; above the claw just back of the hinge there is an obtuse chitinous projection, figure 189, and at the base of each proleg there is a long rapier-like projection, figure 189;

on the under side of the proleg near the base there is a chitinous hook directed backward, figures 187, 189.

In a few of the alcoholic specimens examined there are finger-like anal gills. It seems probable that anal gills are constant in the species, but are protruded in preserved specimens only under exceptional conditions.

THE CASE.—As previously stated, the larva makes no case until it begins to prepare for pupation. It then crawls within some crevice between large stones and builds a fence-like wall of pebbles about itself. The fence is oval in outline and is many times larger than the body of the insect. Inside its inclosure the larva spins about itself a close-fitting, parchment-like sheet of silk, superficially resembling the puparium of the higher Diptera. Here transformation takes place.

RHYACOPHILA TORVA.

LARVAL HABITAT.—The half-dozen larvæ which have been collected in the region were taken in three of the nearby gorges leading into the Cayuga Lake Valley. The large number of adults occurring in all of the gorges indicates that the species is a common one in the swift waters of the region.

LARVAL HABITS.—When collected our specimens were not distinguished from *R. fuscula,* which the species probably closely resembles in habits.

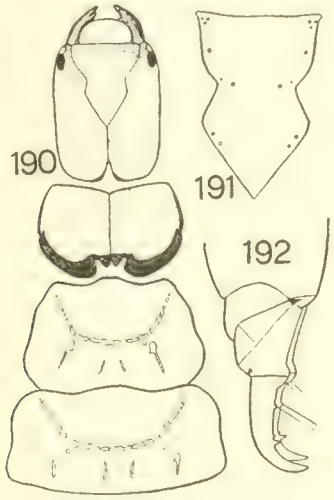
PREPUPAL HABITS.—The prepual habits of the species were not observed.

PERIOD OF EMERGING.—Adults are on the wing during the month of June.

DESCRIPTION OF LARVA.—Length, 20 mm. Head, long and flat, with parallel sides.

The Head.—The color of the head is straw yellow, shading into brown behind the mouth parts; behind each eye there is a jet black subcuticular mark, and the caudal margin is narrowly bordered with black, figure 190. The labrum is very weakly chitinized; both mandibles have long teeth, much more deeply notched than those of *R. fuscula;* the mandible of the left side is broader than that of the right side.

The Thorax.—The prothorax above is straw yellow, with a caudal margin of deep black; each episternum is extended forward in a spine-like process which has a black dorsal spot; the legs are straw yellow.



RHYACOPHILA TORVA.

190. Larva. Head and thorax.
191. Larva. Frons.
192. Larva. Prolegs, lateral view.

The meso- and meta-thorax are brown in alcoholic material, marked with light yellow, as in figure 190; the second and third pairs of legs are almost white.

The Abdomen.—The abdomen is narrower and less flattened than that of *R. fuscula,* the constrictions between segments are not quite so deep, and dorsal furrows of the integument are absent. Each segment has a similar dorsal pattern of light color, as shown in figure 190. The drag-hooks, figure 192, are slender and very simple compared to those of *R. fuscula;* there are no lateral spine-like elongations of the chitin, no dorsal humps at the base of the claws, and no ventral back-turned hooks. The drag-hooks are long and slender and comparatively weak.

Description of Case.—We have made no observations on the case-building habits of the species. Vorhies, who reared it in Wisconsin, states that "the larva lives in a loosely-built case of gravel," and "at the time of pupation this becomes a strong, irregu-

lar hemi-ellipsoid, measuring 10 mm. wide by 15 mm. long." In our collection a single specimen in the prepupal state is inclosed in a puparium-like sheet of silk, like that made by *R. fuscula*.

Sub-family Glossosomatinæ.

Description of Larvæ.—The head is rounded, not long and flattened. The abdomen is round in cross-section, with normal inter-segmental constrictions. The prolegs are short and extend at right angles to the long axis of the body; their claws are weak. The maxillary lobes are short and broad.

Glossosomatinæ.

A. Meso- and meta-notum each with a pair of chitinous plates.—*Agapetus*.

A.A. Meso- and meta-notum entirely soft.—*Glossosoma*.

Glossosoma Americanum.

Larval Habitat.—The larvæ are found in all swift waters of the region, but reach their greatest abundance in the riffles of the upland streams. In the parts of streams with stony bottoms in the McLean and Freeville swamps the larvæ occur in extraordinary abundance, their cases completely covering the sides of nearly all submerged stones.

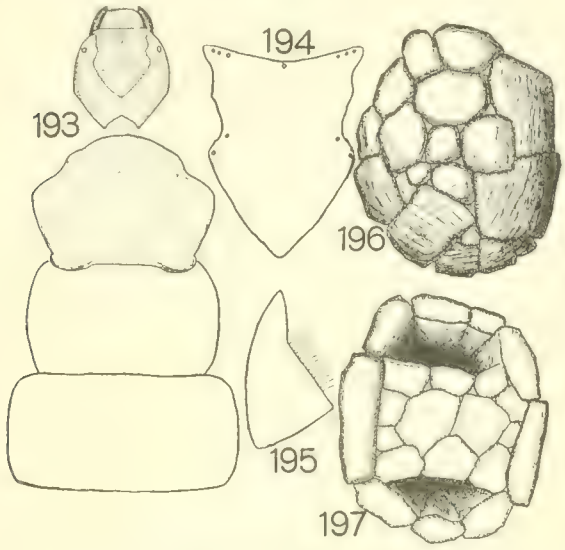
Larval Habits.—From the time of hatching until the prepupal stage the larvæ live singly on the stones of the stream's bottom. Before pupating they congregate in dense colonies on the sides and bottom of stones, with their cases placed edge to edge—sometimes one on top of another. It is during this prepupal stage that the larvæ are most often encountered.

Food of Larvæ.—Stomachs of a large number of specimens were examined. All contained a light-colored material, the cellular nature of which could not be determined.

Prepupal Habits.—In the prepupal state the larvæ develop a gregarious habit—large numbers congregating in small areas. At this time the floor of the case is cut away and the entire rim of the cup-like roof is securely glued to some solid support. Under this cover the puparium-like cover is spun around the larva.

PERIOD OF EMERGING.—The species is found as larvæ, pupæ, and adults during the entire summer.

DESCRIPTION OF LARVA.—Length, 9 mm. In cross-section the body is round. It assumes a curved position, especially marked toward the caudal end of the abdomen.



GLOSSOSOMA AMERICANUM.

193. Larva. Head and thorax.
194. Larva. Frons.
195. Larva. Mandible.
196. Case of larva, dorsal view.
197. Case of larva, ventral view.

Head.—The head is small compared to the thoracic segments. It is light-brown without a pattern, except a light-colored area around each eye and indistinct muscle-attachment marks. The mandibles, figure 195, are alike; each has a sparse fringe of pale hairs on its inner margin; in color they are brown. The labrum is shown at the base, with pale outer margins which bear numerous short, light-colored hairs.

Thorax.—The prothorax, figure 193, is heavily chitinized above; it is nearly uniform brown in color; on the ventral side there is a brown chitinous plate covering the entire lower surface of the segment; the horn is absent.

The meso- and meta-thorax are without chitinous dorsal plates.

Each of these segments bears an indistinct pattern of pale, narrow marks on its soft dorsal surface.

Abdomen.—The abdomen is without external gills. The prolegs are turned at right angles to the axis of the body, and bear drag-hooks of extremely small size, which are apparently put to but little use.

Description of Case.—The case of the larva, figures 196, 197, is made of small pebbles or large sand grains. In form it appears much like a diminutive turtle. On the lower side, figure 197, there is a floor of sand grains built across the middle of the case, leaving the two ends open on the bottom, but completely covered on the upper surface. This case is freely movable over the surface of rocks.

The case of the pupa differs from the case of the larva only in having no floor. The rim of the case is tightly cemented to some submerged rock, and inside of the inverted cup thus formed the cocoon is spun and pupation takes place.

Genus Agapetus.

An unreared species of the subfamily Glossosomatinæ, which agrees well with published European descriptions of the genus Agapetus, was collected in Michigan Stream above Spencer Lake.

The larvæ differ from the larvæ of the genus Glossosoma in having a pair of large chitinous shields on the mesothorax and a pair of smaller shields on the metathorax. The prolegs and drag-hooks are larger than those of Glossosoma.

The cases are similar to those made by Glossosoma, but larger pieces of gravel are used in their construction.

FAMILY HYDROPTILIDÆ.

This family contains the most minute members of the order Trichoptera. For this reason, no doubt, it is the most neglected family in the order. Scarcely the first step has been taken toward a knowledge of the immature stages in America, and even the adults are most imperfectly known. In the present stage of our knowledge no attempt at classification is possible.

The tiny larvæ inhabit standing or flowing waters, and often occur in very great numbers. Often their cases completely cover

the edges of rocks in swift streams, or hang in masses in waving tufts of Cladophora.

The cases of the described species are all portable, except those of *Ithytrichia confusa,* which is tightly cemented to rocks in moving water. The cases vary greatly in form in different species. For the most part they are made of pure silk, but some have a sparse interweaving of sand grains or filaments of green algæ.

Description of the Larvæ.—The mandibles are asymmetrical. The antennæ are large, almost as long as the mandibles. Each thoracic segment bears a four-cornered shield. The prosternal horn is lacking. The middle of the abdomen is much larger than the thorax; spacing-humps are absent. The dorsal surface of the abdominal segments often bears chitinous plates. The prolegs are short, with short, stout claws.

The chitinous armature of the larvæ offers excellent characters for classification which, together with the interesting habits of the species, offers a promising field for future investigation.

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A bibliography of the more important works is contained in "Studies on the Trichoptera of Wisconsin," by Charles T. Vorhies, Transactions of the Wisconsin Academy of Sciences, Arts, and Letters, 1909.

The most important key to the North American Trichopterous larvæ, Krafka, 1915, is quite satisfactory for determining most species to the family or subfamily, but makes no attempt to classify genera and species.

A number of authors have published more or less on the habits of caddis-worms. No doubt the most important of these is the work of Dr. Vorhies, 1909, in which are described the immature stages of nineteen species, with careful notes on their habits.

Preceding the work of Dr. Vorhies, Miss Cora H. Clarke published two articles, 1882 and 1901, in which she described and figured the cases of more than twenty species. Many of the determinations in this article go no farther than the genus, and sometimes no attempt at classification is made. The figures of the cases are good and many accurate notes on the habits of the larvæ accompany them. That the author used more than usual care in observing her specimens is shown by her figure of the respiratory grating of the case of Neophylax (unnamed in her article) and her mention of the "spinnaret" of the larva "Plectronemia." Without doubt this was a species of Phylocentropus.

There are no more accurate figures and notes on the cases of the larvæ and pupæ of Trichoptera than are furnished by the work of Miss Clarke.

The habits of the net-spinning caddis-worms of swift water have been carefully described by Miss Noyes, 1914. A more detailed account of the net-spinners, together with a description of the larvæ and pupæ, has been prepared by Miss Noyes and is forthcoming in a bulletin of the New York State Museum.

Dr. Cornelius Betten has prepared a careful monograph of all stages of North American Trichoptera, which will soon appear as a bulletin of the New York State Museum. After the appearance of this work much of the difficulty of determining species will be removed and, no doubt, the study of the order will be greatly stimulated.

The bibliographical references in this paper cover all of the important writings on the immature stages of North American Trichoptera known to us. Many excellent papers have appeared on the immature stages of the European species, reference to which will be found in the aforenamed bibliographies. Much use has been made of many of these works in the preparation of the present paper, especially to the part on Trichoptera, Heft 5/6, of the "Süsswasserfauna Deutchlands," by Georg Ulmer.

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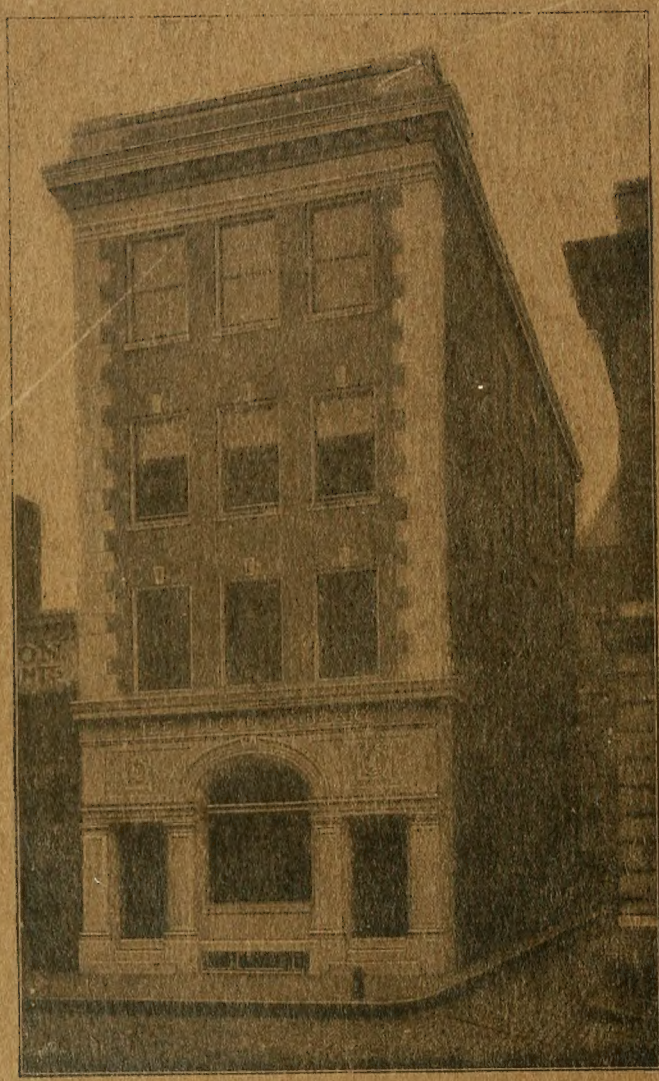

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